Final
Remedial Investigation Work Plan
Upper Blackfoot Mining Complex

Lewis and Clark County, Montana

Prepared for:

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Table of Contents

List of Tables

List of Figures

Figures are located at the end of each section.

Appendices

ACRONYMS AND ABBREVIATIONS

µm	micrometer
µmhos/cm	microhmos per centimeter
^{0}C	degrees Celsius
ABA	Acid-Base Accounting
AET	Apparent Effects Thresholds
AMSL	above mean sea level
AN	Anaconda Mine Site
AOC	Administrative Order on Consent
ARCO	Atlantic Richfield Company
ARD	Acid Rock Drainage
ASARCO	American Smelting and Refining Company
ASTM	American Society of Testing and Materials
BCMW	Beartrap Creek Monitoring Well
BER	Board of Environmental Review (Montana)
BERA	Baseline Ecological Risk Assessment
BFR	Blackfoot River
bgs	below ground surface
BLM	U.S. Bureau of Land Management
BTC	Beartrap Creek
BTEX	Benzene, toluene, ethylbenzene, xylenes
CDM	Camp Dresser & McKee Inc.
CECRA	Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
cfs	cubic feet per second
cm	centimeter
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CSEM	Conceptual site exposure model
cy	cubic yard
DEQ	Department of Environmental Quality (Montana)
DI	Deionized
DNRC	Department of Natural Resources and Conservation (Montana)
DQO	Data Quality Objective
DRO	diesel range organics
DSR	Comprehensive Data Summary Report (DEQ 2007)
EA	Environmental Assessment
ECO-SSL	Ecological soil screening level

ED	Edith Mine
EE/CA	Engineering Evaluation/Cost Analysis
Eh	Redox Potential
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ERCLs	Environmental Requirements, Criteria or Limitations
FSP	Field Sampling Plan
ft	feet
FWP	Fish, Wildlife and Parks
gpd/ft	gallons per day per foot
gpm	gallon per minute
GWIC	Groundwater Information Center
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HI	Hazard index
HQ	Hazard quotient
HRS	Hazard Ranking System
ILS	In Line (Oxidation) System
IP	Implementation Plan (Temporary Water Quality Standards)
IRIS	Integrated Risk Information System
km	kilometer
lb/day	pound per day
LC	Lower Carbonate Mine Site
m	meters
MAEL	Minor Adverse Effects Levels
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MDHES	Montana Department of Health and Environmental Sciences
MDSL	Montana Department of State Lands
MFG	McCulley, Frick, and Gilman
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MGWPCS	Montana Groundwater Pollution Control System
MHMMC	Mike Horse Mining and Milling Company
MHMS	Mike Horse Mine Site
mL	milliliter
mm	millimeter
MPDES	Montana Pollutant Discharge Elimination System
MPP	Mary P Prospect
MSD	minimum search distance

MW	Monitoring well
NBS	National Bureau of Standards
NCEA	National Center for Environmental Assessment
NEL	No Level Effects
NFSR	National Forest System Road
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priorities List
NRCS	National Resource Conservation Service
O&M	Operations and Maintenance
OEHHA	Office of Environmental Health Hazard Assessment
ORNL	Oak Ridge National Laboratory
PAET	Probable apparent effects threshold
PCB	Polychlorinated Biphenyls
PEL	Probable Effects Level
pH	a measure of acidity or alkalinity of a solution
PLPs	Potentially Liable Persons
PM	Paymaster Mine
ppb	parts per billion
ppm	parts per million
PPRTV	Provisional Peer-Reviewed Toxicity Values
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RD	Remediation Division (DEQ)
RfD	Reference dose
RI	Remedial Investigation
RIWP	Remedial Investigation Work Plan
SAP	Sampling and Analysis Plan
SC	Specific Conductance
SED	Sediment
SF	Slope factor
SI	Site Investigation
SLERA	Screening level ecological risk assessment
SMP	Shoemaker, McLean, and Pratt
SOP	Standard Operating Procedure
SW	Surface Water
T	tons
TD	Mike Horse Tailings Dam
TEL	Threshold Effects Level
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load

TPH	Total Petroleum Hydrocarbons
TRC	Total Recoverable
TSS	Total Suspended Solids
UBMC	Upper Blackfoot Mining Complex
UC	Upper Carbonate Mine Site
UET	Upper Effects Threshold
UMHMW	Upper Mike Horse Monitoring Well
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VCRA	Voluntary Cleanup and Redevelopment Act
XRF	x-ray fluorescence
yd	yard

EXECUTIVE SUMMARY

The Upper Blackfoot Mining Complex (referred to as “UBMC”, “UBMC Facility”, or “Facility”) includes a mixture of National Forest and private lands that lie within a portion of the historic Heddleston Metal Mining District, (Heddleston District) in the Rocky Mountains of Lewis and Clark County, Montana (**Figure 1-1**). The UBMC Facility is located about 15 miles east of Lincoln, Montana, in the headwaters area of the upper Blackfoot River. The UBMC is comprised of a number of individual historic underground mines that developed deposits occurring principally as narrow, fault-controlled, base-metal (silver-lead-copper-zinc) veins.

Mining activity at the UBMC began with the discovery of silver-, lead-, and zinc-bearing ores in about 1880 (GCM 1993). Sporadic development and production occurred at these mines between the late 1800s and the 1940s with more than 95 percent of the district’s total production (450,000 tons) occurring at the Mike Horse Mine in the 1930s and 1940s. Limited mining activity took place under various leases through the late 1950s. The American Smelting and Refining Company (ASARCO) acquired most of the patented (privately owned) mining claims in the district when it purchased the Mike Horse Mining and Milling Company (MHMMC) in the 1940s, and additional claims from the Atlantic Richfield Company (ARCO) in the early 1980s. Other smaller mines and mining prospects are located within the UBMC (see GCM 1993), as well as throughout the Blackfoot River drainage; most have been inactive since at least the mid-1950s.

As a result of this historic mining activity, the UBMC contains hard rock mining wastes and acidic discharges that impact the environment. Human health and environmental issues are related to elevated levels of heavy metals present in mine waste piles, tailings, acidic metal-laden surface and groundwater, water discharging from mine adits, and contaminated waste redeposited as stream sediments. Numerous investigations have been conducted over the last 20 years to characterize contamination in mine wastes. Contaminants at the Facility include, but are not limited to, arsenic, cadmium, copper, lead, iron, manganese, and zinc.

ASARCO conducted mine reclamation activities at the UBMC from 1993 through 2007. Portions of the reclamation program were completed with ARCO participation. Reclamation activities have focused on seven individual mines all of which are located on patented mining claims owned by ASARCO. Reclamation activities included mine waste removals from select mine sites to three on-site repositories, reclamation of some mining wastes in place, and the installation of a semi-passive treatment system for adit-water discharge from the Mike Horse and Anaconda Mine adits. Much of this work was completed without Department of Environmental Quality (DEQ) approval.

Currently, the UBMC mine reclamation program is proceeding under the jurisdiction of both state and federal regulatory programs. The UBMC falls under jurisdiction of the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA) program and is identified as a high priority facility on the CECRA priority list (http://deq.mt.gov/StateSuperfund).

The Montana legislature has directed DEQ to complete a Remedial Investigation (RI) at the UBMC. DEQ prepared a Comprehensive Data Summary Report (DSR) for the UBMC with assistance from Tetra Tech and the final report will be issued in December (DEQ 2007). That report 1) presents a compilation of all existing and available information relevant to the UBMC; 2) evaluates the data by comparing it to appropriate screening levels; and 3) identifies additional data gaps.

In the fall of 2007, Tetra Tech entered into a contract (Contract No. 407036, Task Order No. 9) with DEQ to perform the services necessary to complete work plans, field activities, and reports associated with completion of an RI for the UBMC Facility. This RI Work Plan (RIWP) is the first of a series of reports in the RI process that has been prepared by Tetra Tech for the DEQ Remediation Division and as such is designed to comply with the requirements of CECRA and DEQ guidance.

The RIWP describes the technical approach, methods, and justification for conducting the RI at the UBMC Facility. The intention is not to conduct an entire site characterization, but rather to build on existing data and identify and fill identified data gaps. The RIWP includes the sampling and analysis plan (SAP) (**Appendix A**), consisting of an integrated field sampling plan (FSP) and a quality assurance project plan (QAPP), and a health and safety plan (HASP).

The principal RI tasks include:

- Project planning;
- Design an RI that builds on existing data;
- Design an RI that identifies and fills data gaps;
- Collecting data necessary to conduct the baseline risk analysis;
- Collecting data necessary to support development and evaluation of remedial alternatives; and
- RI report preparation.

The RIWP is organized into several sections. The introductory section (Section 1.0) describes the mining and regulatory history of the UBMC Facility and general site physical characteristics with particular emphasis on the site geology and hydrology. Following this introductory section is a summary of mine reclamation activities completed to date by ASARCO and ARCO (Section 2.0). Section 3.0 describes what is known of the existing nature and extent of contamination within the UBMC by examining various media including mine wastes, soils, surface water, surface water sediments, groundwater, and benthic macroinvertebrates. Contaminant fate and transport including sources, release mechanisms, migration pathways, attenuation mechanisms, risk analysis approach, and the development of a site-wide conceptual model are presented in Section 4.0. Section 5.0 presents a discussion and list of 2007 / 2008 work plan tasks, and Section 6.0 present major aspects of the overall project management. A list of references cited in this report concludes the work plan as Section 7.0.

The specific purpose of the work plan is to describe the process and activities that are proposed by DEQ to:

- Compile the available information to identify, characterize, and define the sources of contaminants in mine wastes at the UBMC Facility;
- Investigate the chemical nature and extent (area of impact and volume of material) of known and suspected sources, including mine waste rock, tailings, contaminated transported and redeposited sediments, reclaimed waste rock removal areas, modern stream sediments, and other contaminated soils at the UBMC Facility;
- Investigate the nature, extent, and migration of contamination across and through the site by surface and groundwater including water chemistry, chemical loading, and flow rates from known adit discharges to surface or groundwater. In addition, this investigation will describe alluvial and bedrock aquifer characteristics; contamination in groundwater and surface water (predominantly metals), acid loading to surface water from various sources, and recent stream sediment. The degree of interaction and connectivity of surface water and groundwater aquifers will also be described. Part of this investigation will focus on delineating the lateral and vertical extent of contamination in groundwater. Additional surface and groundwater quality and quantity (flow) data will be collected. Finally, an appropriate number of samples will be collected to establish background concentrations of potential contaminants of concern in soils, recent stream sediments, surface and groundwater;
- Develop a site-wide conceptual model for contaminant sources, release mechanisms, migration pathways, and attenuation mechanisms;
- Characterize the risks at the Facility. This investigation will gather data needed to evaluate risks to human health and the environment. The investigation will characterize (from an RI standpoint) contaminated media and identify likely exposure pathways and receptors; and,
- Present a plan to collect all site-specific data that are both sufficient and necessary to develop and evaluate viable remedial alternatives for inclusion in the feasibility study.

Site specific sampling (Section 3.0; and in the SAP, **Appendix A**) is designed to characterize the site, provide data necessary for a human health and ecological risk assessment of contaminants associated with various media, and to provide data in support of the selection and design of remedial action alternatives. Site-specific sampling needs are identified in the SAP (**Appendix A**) to achieve these goals, and the rationale for each sample type is provided. These sampling needs are summarized in a more general fashion in Section 5.0.

The optimized sample design includes:

- Collection of data to establish background concentrations of contaminants in soil, stream sediments, and water;

- Collection of data to characterize contaminated soils associated with mining wastes;
- Collection of data on surface water quality and flow;
  - review of loading analysis based on historical data,
  - delineation of gaining and loosing reaches of streams, and,
- Collection of data on groundwater quality and water levels;
  - collection of groundwater aquifer characterization data, and,
  - collection of data to determine the lateral and vertical extent of groundwater contamination,
  - collection of data to characterize the groundwater-surface water interaction,
- Collection of data to characterize eroded, transported, and redeposited contaminated sediments in stream channels;
- Collection of aquatic macroinvertebrates to characterize aquatic health of stream segments;
- Collection of data necessary to quantify the human health and environmental risks at the Facility;
  - characterize contaminated media from a risk analysis standpoint, and,
  - identify likely exposure pathways and receptors,
- Collection of data needed to support evaluation of likely remedial alternatives,
- Collection of data for fate and transport analysis.

Finally there are a few other specific tasks that have been identified and need to be completed during the RI process (prior to the preparation of the RI Report). These tasks include:

- Understanding the reasons for and evaluating past, current, and proposed reclamation actions by ASARCO/ARCO and their effectiveness (waste rock removal areas, in place reclamation, repository closures, and water treatment facilities);
- Revegetation performance monitoring; and
- Completion of tasks for the RI Report not requiring additional field work.

New data will supplement the information compiled in previous site investigations. All available site data will then be incorporated in an RI report to be completed for a separate task (Task No. 7) under Task Order 9. All of these tasks will be conducted in accordance with CECRA, as well as DEQ and EPA guidance, as appropriate.

The contract to complete Task Order No. 9 was signed on August 7, 2007. Identification of data gaps and the development of a 2007 SAP began immediately after the signing of the contract. Field work for the 2007 fall expeditious sampling event began on October 3, 2007 and was largely completed by October 26, 2007. The Draft RIWP was submitted to DEQ on October 31,

2007. DEQ commented on the Draft RIWP and a Draft Final RIWP was submitted to DEQ on December 3, 2007. The Final RIWP will be submitted after DEQ comments on the inclusion of the results for the fall 2007 Season-Specific Investigation report (completion of Task 3), which is expected to be completed by December 31, 2007. The Final RIWP document will include additional data gaps identified during the 2007 field/sampling program and layout the 2008 sampling program to fill the identified gaps and gather the required data for the completion of the RI Report. The Draft RI Report will be submitted after site characterization is complete. The Final RI Report is due by January 30, 2009.

1.0 INTRODUCTION

The Upper Blackfoot Mining Complex (referred to as “UBMC”, “UBMC Facility”, or “Facility”) includes National Forest and private lands that lie within a portion of the historic Heddleston Metal Mining District (Heddleston District), in the Rocky Mountains of Lewis and Clark County, Montana (**Figure 1-1**). The Heddleston District is located about 15 miles east of Lincoln, Montana, largely south and east of US Highway 200, in the headwaters area of the Blackfoot River. The UBMC is comprised of a number of individual historic mines, including the Carbonate, Midnight Hill, Mary P, Edith #2, Paymaster, Capitol, Consolation, Anaconda, and Mike Horse mines. Mined deposits occur principally as fault-controlled, narrow base-metal (silver-lead-copper-zinc) veins that are related to a Tertiary-age intrusive complex. **Figure 1-2** is a map that depicts the existing conditions at the Facility and presents a number of features that will be referred to throughout the discussions in this work plan.

Mining activity at the UBMC began with the discovery of silver-, lead-, and zinc-bearing ores in about 1880 (GCM 1993). Sporadic development and production occurred at these mines between the late 1800s and the 1940s with more than 95 percent of the district’s total production (450,000 tons) occurring at the Mike Horse Mine beginning in the late 1930s and continuing through the mid-1940s. More limited mining activity took place at the Mike Horse and Anaconda mines under various leases from the late 1940s through the late 1950s. American Smelting and Refining Company (ASARCO) obtained mining claims in the district when it purchased the Mike Horse Mining and Milling Company in the 1940s, and obtained additional claims when ASARCO purchased holdings of the Atlantic Richfield Company (ARCO) in the district in the early 1980s. Other smaller mines and mining prospects are located within the UBMC (see GCM 1993), as well as throughout the Blackfoot River drainage. Most of the other mines in the Heddleston District have been inactive since at least the mid-1950s.

As a result of this historic mining activity, the UBMC contains hard rock mining wastes and acid discharges that affect human health and the environment. Human health and environmental issues are related to elevated levels of heavy metals present in mine waste piles, tailings, acidic metal-laden surface and groundwater, water discharging from mine adits, and contaminated waste redeposited as stream sediments.

ASARCO LLC, (ASARCO, formerly ASARCO, Inc. and American Smelting and Refining Company) conducted mine reclamation activities at the UBMC from 1993 through 2004. Portions of the reclamation program were completed with ARCO participation. Reclamation activities have focused on seven individual mines (the Carbonate, Edith #2, Paymaster, Capitol, Consolation, Anaconda, and Mike Horse mines) all of which are located on patented mining claims owned by ASARCO (**Figure 1-2**). Reclamation activities included mine waste removals from some of these mine sites to three on-site repositories and the installation of a semi-passive treatment system for adit-water discharge from the Mike Horse and Anaconda adits. Much of this work was completed without DEQ approval.

Currently, the UBMC mine reclamation program is proceeding under the jurisdiction of both state and federal regulatory programs; a detailed UBMC regulatory history is presented in Section 1.4.3. The UBMC falls under jurisdiction of the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA) program and is identified as a high priority facility on the CECRA priority list (http://deq.mt.gov/StateSuperfund).

The Montana legislature has directed the Department of Environmental Quality (DEQ) to complete a Remedial Investigation (RI) at the UBMC. Site assessment activities have been summarized in the Comprehensive Data Summary Report for the Upper Blackfoot Mining Complex, Lewis and Clark County, Montana (DEQ 2007). Supplemental data also exists from historical investigations and other activities performed from 2005 forward, including an Environmental Engineering/Cost Analysis (EE/CA) that was produced by ASARCO for the United States Department of Agriculture Forest Service (USFS) (Hydrometrics 2007). Investigations were conducted to characterize contamination in mine waste, mine tailings, soil, sediment, groundwater, and surface water. Contaminants at the site include, but are not limited to, arsenic, cadmium, copper, lead, iron, manganese, and zinc.

In the summer of 2007, a Task Order agreement (Task Order No. 9) was entered into between DEQ and Tetra Tech Inc. (Tetra Tech) pursuant to DEQ Contract No. 407036. The purpose of this Task Order is to perform the services necessary to complete work plans, field activities, and reports associated with completion of an RI for the UBMC Facility near Lincoln, Montana. This RIWP is the first of a series of reports in the RI process and is designed to comply with the requirements of CECRA and current DEQ guidance.

1.1 PURPOSE, SCOPE, AND OBJECTIVES

The most significant environmental issues within the UBMC are associated with impacts from historic mining activities that began with the prospecting of the area in about 1889, but are principally related to mining activities that occurred from the late 1930s through the late 1950s. Human health and environmental issues are primarily related to elevated levels of heavy metals present in mine waste piles, tailings, acidic metal-laden water discharging from mine openings, contaminated surface and groundwater, and the transport and redeposition of contaminated mine wastes as in-stream sediments.

This work plan was developed by Tetra Tech for DEQ and relied heavily on the data and analysis presented in the Data Summary Report (DEQ 2007). A major objective of this RIWP is to present the technical approach, methodology, and justification for conducting the RI at the UBMC Facility.

The purpose of the work plan is to describe the process and activities that are proposed by DEQ to:

- Summarize the available information to identify, characterize, and define sources and historic releases at the UBMC Facility;

- Delineate the nature and extent of the contamination in mine wastes, soils, surface water, sediments, and groundwater;
- Develop a site-wide conceptual model for contaminant sources, release mechanisms, migration pathways, and attenuation mechanisms;
- Present a plan to identify, compile and collect the data necessary to prepare baseline risks assessments for human health and the environment; and,
- Present a plan to collect all site-specific data that is both sufficient and necessary to develop and evaluate viable remedial alternatives.

The RIWP has been prepared using guidance and methodology provided by DEQ's Remediation Division and EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final* (EPA 1988) for characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and evaluating potential remedial options. The primary objective of the work plan is to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for the remediation of the Facility.

For purposes of this work plan, the geographic scope of UBMC is defined as the area of historic mining of the Heddleston District and surrounding lands. This includes the drainage area from upgradient of the Mike Horse Mine and tailings impoundment, downstream to the natural marsh system where Swamp Gulch (site of the reclaimed Carbonate Mine) enters the Blackfoot River (**Figure 1-2**). This area generally coincides with the lands that received the majority of the mine reclamation actions in the last 15 years and includes the area covered by the USFS EE/CA (Hydrometrics 2007b). This general geographic description of the UBMC is intended to support development of the work plan and is not intended to delineate the CECRA definition of a Facility, which includes "any site or area where a hazardous or deleterious substance has been deposited, stored, disposed of, placed, or otherwise come to be located." Until existing data gaps regarding the nature and extent of contamination are filled, the CECRA "Facility" will not be fully defined. Other historical and recent studies, including surface water sampling and aquatic macroinvertebrate studies have been carried out further downstream along the Blackfoot River to its junction with the Landers Fork about ten miles east of Lincoln, Montana.

The geographic extent of the work plan's sampling and analysis varies for different environmental (contaminant) media. For soil, mine waste, and groundwater data, the data collection encompasses the area described above for the UBMC (i.e., upstream of Swamp Gulch and the reclaimed Carbonate Mine). For surface water, benthic macroinvertebrate and sediment sampling, the data collection extends further downstream, to the Highway 279 crossing of the Blackfoot River **Figure 1-1**.

Based on the extensive historical environmental monitoring and data collection undertaken by various entities in the Blackfoot River drainage over the past 30 years or more, a systematic approach is used for review and discussion of past sampling results. In this work plan, the description of the nature and extent of contamination at the Facility (Section 3.0) is approached by presenting a summary statement or discussion where appropriate, regarding background samples and data, pre-reclamation sampling, and post-reclamation sampling that is relevant to characterizing existing site conditions. This is followed by a discussion of recent DEQ 2007 sampling, which was designed to fill obvious data gaps and verify the results of some historical sampling; and a brief discussion of historical and recent results (most recent data is not available at this time for analysis). Finally, there are sections for the various sampled media that define additional data gaps identified to date, and proposed (2008) plans to fill those gaps in order to provide the data necessary to prepare the RI Report.

1.2 REPORT ORGANIZATION

This work plan is organized into the following sections:

- **Section 1.0** Describes the mining and regulatory history of the site, and general site physical characteristics with particular emphasis on the site geology and hydrology.
- **Section 2.0** Summarizes mine reclamation activities completed to date by ASARCO and ARCO.
- **Section 3.0** Describes the existing nature and extent of contamination within the UBMC by examining various media including mine wastes, soils, surface water, surface water sediments, groundwater, and benthic macroinvertebrates.
- **Section 4.0** Discusses contaminant sources, release mechanism, migration pathways, attenuation mechanisms, risk analysis approach, and the development of a site-wide conceptual model.
- **Section 5.0** Presents a discussion and list of 2007 / 2008 work plan tasks.
- **Section 6.0** Presents major aspects of the overall project management.
- **Section 7.0** Lists references cited in this report.

Several documents are appended to this work plan. The 2008 Sampling and Analysis Plan (SAP) is appended in **Appendix A**. The Quality Assurance Project Plan (QAPP) is included in **Appendix A** as Section 4 of the SAP. The Health and Safety Plan (HASP) is included in the SAP as Appendix A-1. Supporting documentation and information is included in other appendices.

1.3 SITE LOCATION AND DESCRIPTION

The UBMC and the Heddleston District contain both federally-owned lands (National Forest System) and private lands (ASARCO Patented Mining Claims, ASARCO Fee lands and other private property) within the boundaries of the Lewis and Clark National Forest and within Lewis and Clark County, Montana (**Figure 1-1**). The UBMC lies predominantly south of US Highway 200, about 15 miles east of the community of Lincoln, Montana (population 1,100) and about 5 miles west of Rogers Pass, which crosses the Continental Divide.

The UBMC covers an area of about 6 square miles located in Sections 16, 17, 18, 19, 20, 21, 22, 27, 28, 29, 31, 32, 33, and 34 of Township 15 North, Range 6 West (**Figure 1-2**).

The UBMC is characterized by heavily forested, steep mountainous terrain, with elevations ranging from 5,200 feet above mean sea level (AMSL) at the confluence of Pass Creek and the Blackfoot River (near the head of a major marsh system, **Figure 1-1**), to over 7,500 feet AMSL in the drainage headwaters along the Continental Divide.

The UBMC is situated near the headwaters of the Blackfoot River. Major tributary streams include Mike Horse Creek, Beartrap Creek, Anaconda Creek, Stevens Gulch, Shave Creek, Paymaster Creek, Pass Creek, Swamp Gulch, and Meadow Creek (**Figure 1-1**). The Blackfoot River proper is formed at the confluence of Beartrap and Anaconda Creeks.

1.4 SITE HISTORICAL OVERVIEW

1.4.1 Mining History Overview

The Heddleston District was named for William Heddleston who, with his partner George Padbury, discovered the Calliope lode in 1889 (GCM 1993). A small mining operation was begun and an arrastra was built on Pass Creek to process the ore. Prior to 1915, prospectors discovered a number of lodes containing lead, zinc, and copper, including the Mike Horse, Carbonate, Paymaster, Midnight, and Anaconda mines. The district's early development was hampered by difficult access into the district created by the lack of suitable roads. As a result, only minor shipments of ore were made to off-site smelters during this early period of mining.

The district saw a revival of mining activity in 1915 when the Mike Horse Mine was taken over by the Sterling Mining and Milling Company of Ellensburg, Washington. A major lead deposit was developed at the Mike Horse Mine and in 1919 a (jig) concentrating mill was built to process the mine's ores, as well as the ore from the nearby Anaconda and Paymaster mines. The Mike Horse Mine produced a modest amount of ore as concentrate by the end of the 1920s. The Mike Horse Mine was idle until 1938 when it was leased to the Mike Horse Mining and Milling Company. The following year, a 150 tons-per-day flotation mill was built, and, in 1940, a 15-mile electric power line was strung from Marysville to the mine. In 1941, the Mike Horse Dam was constructed across Beartrap Creek just upstream of the confluence with Mike Horse Creek (**Figure 1-1**) to serve as an impoundment for the tailings from the newly constructed Mike Horse Mine flotation mill. The Mike Horse deposit produced lead/zinc ore, containing some silver, continuously, for the next decade (GCM 1993).

In 1945, the assets of the Mike Horse Mining and Milling Company were purchased by ASARCO, and it kept the Mike Horse Mine operating until 1955, at which point the mine closed due to declining metals prices and near exhaustion of the ore body. The Rogers Mining Company of Helena leased and operated the mine sporadically from 1958 until early 1964 when the Anaconda Company of Butte acquired lease rights to the Mike Horse Mine from ASARCO through lease agreements. The Anaconda Company conducted exploration activities from 1962 through 1973 in the Heddleston District (although not on the Mike Horse Mine claims), including detailed geologic mapping; geochemical sampling; drilling of 340 rotary, diamond, and reverse circulation drill holes; and driving of 2 bulk sampling adits. This exploration work defined the substantial underground copper/molybdenum porphyry ore body. In 1979, following cessation of the Anaconda Company's exploration activities in the Heddleston District, the Anaconda Company was merged into ARCO. ASARCO purchased all of ARCO's holdings in the Heddleston District in 1981. From 1981 to present, ASARCO has performed limited exploration work on the property, as well as mine reclamation activities (with ARCO's participation).

Although the Mike Horse Mine was the mainstay of the district, other small mining operations were also active during the twentieth century. The Paymaster was in operation early in the 1900s but had closed by the mid-1920s. In the early 1960s, it was reopened with minor development work conducted by Paramount Estates of New York. The Anaconda Mine was developed early in the 1900s and produced minor amounts of ore containing gold, silver, copper, and lead intermittently through 1940. Both properties were purchased by the Anaconda Company in the mid-1960s, and subsequently acquired by ASARCO.

The preponderance of the district's mineral wealth came from the production of base metals such as lead and zinc. Total tonnage of ore produced from the Heddleston District is less than 450,000 tons, with 385,000 tons of that production coming from the Mike Horse Mine from 1945 to 1952. Although exact production figures for the district are not available, it appears that greater than 95 percent of the production from the district came from the Mike Horse Mine with only minor amounts of production coming from the Anaconda, Carbonate, and Paymaster mines.

1.4.2 Land Ownership

The Lewis and Clark County records for land ownership were queried to identify all parcel owners within the UBMC and lands immediately west of the UBMC (Lewis and Clark County 2006). This land ownership is shown on **Figure 1-3**. A list of parcel owners from the UBMC (historic Heddleston District, approximately the east half of **Figure 1-3**) is provided in **Table 1-1**. Information about the patented mining claims owned by ASARCO is summarized by individual mine sites below (Section 1.5). ASARCO also has title to fee land immediately west of its patented claim holdings in the UBMC (**Figure 1-3**).

1.4.3 Regulatory and Permitting History

Regulatory activities at the UBMC commenced in 1987 when the Montana Legislature allocated funds to the Montana Department of State Lands (now part of DEQ) for reclamation of the Mike Horse Mine under the State's abandoned mine reclamation program, with additional funding allocated in 1989. Montana Department of State Lands performed site characterization activities and reclamation planning from 1987 though 1990, including mine waste removal and water treatment designs. In 1990 however, the Montana Department of Health and Environmental

Sciences (MDHES, now DEQ), determined that potentially liable persons (PLPs) may exist for the Mike Horse site, and the state's reclamation plans were put on hold.

Table 1-1
UBMC Property Ownership

Legal Name	Parcel Owner	Property Description	Grazing (Acres)	Timber (Acres)	Total Area (Acres)
18.92 AC	ASARCO INC	Grazing Land	18.92	0	18.92
MS# 7351, 7352, 7354 Capital Mine Area Denver Lode2, Snowdrift, Capital, Copper Wreath	ASARCO INC	Mine Claims	0	66.17	66.17
MS# 7353, 7356, 7357 Helena, Edith	ASARCO INC	Mine Claims	92	98.18	190.18
Gov't Lt 5; Lt 9; Lts 15-16	ASARCO INC	Agricultural Land	16	62.68	78.68
Gov't Lts 1-3 & 6	ASARCO INC	Agricultural Land	24.98	219	243.98
MS # 9806 Midnight Mine Area Daylight, Copper Gate, Midnight, Sunlight Fraction, Sunset, Yellowstone	ASARCO INC	Mine Claim	X	X	X
MS 9286 Mary P	ASARCO INC	Mine Claim	X	X	X
MS #9286 Anaconda Mine Area Anaconda, Big Dick, Blue Cristle, Copper Bell, Little Joe	ASARCO INC	Mine Claim	22	59.66	81.66
MS #9287 Paymaster Mine Area Black Diamond, Bonanza, Cicero, Jumbo, Paymaster	ASARCO INC	Mine Claim	0	84.75	84.75
MS # 10106 Midnight Millsite	ASARCO INC	Mine Claim	X	X	X
MS# 10502 Consolation Mine Area Blackfoot Belle, Consolation, Golden Eagle	ASARCO INC	Mine Claim	X	X	X
MS# 10105 Tunnel Site Area Eureka, Summit Fraction, Tunnel Site	ASARCO INC	Mine Claim	X	X	X
MS# 10556 Carbonate Mine Area Carbonate No. 3, Carbonate No. 5	ASARCO INC	Mine Claim	2	38.83	40.83
MS# 10557 Carbonate Mine Area Carbonate No. 1, Carbonate No. 2	ASARCO INC	Mine Claim	0	39.4	39.4

Table 1-1
UBMC Property Ownership

Legal Name	Parcel Owner	Property Description	Grazing (Acres)	Timber (Acres)	Total Area (Acres)
NESW	ASARCO INC	Grazing Land	55.05	0	55.05
MS# 10371 Mike Horse Mine Area Black Ore, Detroit, Hog All, Little Nell, Mike Horse, Pine Hill, Sterling	ASARCO INC	Mine Claims	10	128.85	138.85
TR IN SENE 2.67 AC	Bordeleau, Denis B. & Linda M.	Residential Rural	0	0	2.67
TR IN SENE 2.77 AC	Bordeleau, Linda & Denis	Residential Rural	0	0	2.77
E2E2 SWSE	Cox, Esther M.	Agricultural Land	5	195	200
Govt. LTS 1-3 NE4NE4 W2NE4	Cox, Esther M.	Cadotte Cr. Farmstead	41	196.45	239.45
W2SE4	Cox, Lucia L 1/2 Interest	Unknown	0	80	80
NESE	Johnson, Ernest W.	Agricultural Land	0	40	40
SENE	Johnson, Ernest W.	Agricultural Land	9	31	40
Rtc Sportal 17.82 Ac	Lewin-Opitz, Susan	Agricultural Land	0	53.13	58.13
Ms# 10465 Flosse & Louise	Lovely, Mitchell A & Joaquina P	Mine Claim	13	28.26	41.26
Govt Lot 4	Plum Creek Timber Co. LP	Unknown	0	39.87	39.87
Minor Sub #19 Lt 1	Rasmussen, Clifford W. & Ramona	Residential Rural	0	0	0
TR in NWNE 2 AC	Shaw, M. Douglas & Diane R	Residential Rural	0	0	2
Govt LTS All Less Mines	USDA Forest Service	Forest Service	542.62	0	542.62
TR in NWNE .943 AC 1/2 Mile	Zuelke, Robert E. & Kathleen J.	Residential Rural	0	0	0.943

1 From Lewis and Clark County Cadastral parcels
2 Indented names are specific mining claim names

1.4.4 Regulatory and Permitting History

In June 1991, ASARCO and ARCO were identified by the MDHES as PLPs for hazardous or deleterious substance contamination at the UBMC, under CECRA. Required actions identified included development of a Remedial Investigation and Feasibility Study, and implementation of a remedy to be determined by MDHES.

Between February 1992 and May 1993, ASARCO and ARCO met with MDHES regarding implementation of a voluntary remediation program at the UBMC in lieu of the formal RI and Feasibility Study process. Terms and conditions of a voluntary program are outlined in a May 26, 1993 letter from MDHES, including preparation and submittal of annual work plans and other documents. MDHES reviewed but did not approve any of the work. Site reclamation activities proceeded under this agreement until 1998, when certain remedial actions, namely reclamation of the Paymaster Mine and No. 3 Tunnel area, proceeded under the newly established Montana Voluntary Cleanup and Redevelopment Act (VCRA) program.

In 1994, ASARCO applied for and received a Montana Pollutant Discharge Elimination System (MPDES) permit for discharge of treated water from the Mike Horse and Anaconda mine adit discharges. The MPDES permit (MTR-0030031) is still in effect and regulates the discharge of treated water from the wetlands-based water treatment system to the Blackfoot River (Section 2.3). ASARCO also applied for and received a Montana Groundwater Pollution Control System (MGWPCS) permit (permit MGWPCS-001001) in 1996 for treatment and subsurface discharge of a small (2 gallons per minute (gpm) or less) seasonal flow from the Paymaster adit. The Paymaster MGWPCS permit expired in September 2003 and was not renewed, since no discharge was ever recorded from the Paymaster Mine water treatment wetlands cell. ASARCO also holds an authorization to discharge storm water from the UBMC Facility under Montana's general permit for storm water discharges (Authorization MTR300157). The storm water permit remains in effect at the time of this publication.

In 1999, ASARCO petitioned the Montana Board of Environmental Review (BER) for adoption of temporary water quality standards in portions of three streams at the UBMC (Hydrometrics 1999). Temporary standards were requested in portions of Mike Horse Creek, Beartrap Creek, and the upper Blackfoot River. The temporary standards were approved by the BER and were established in the Montana Surface Water Quality regulations (ARM 17.30.630) in June 2000. The temporary standards temporarily modify the water quality standards for a number of metals, including cadmium, copper, iron, lead, manganese and zinc, as well as pH, until 2008. As part of the temporary standards petitioning process, ASARCO was to develop a conceptual plan for mitigation of all "water quality limiting factors" identified in the temporary standards support document, referred to as the Temporary Standards Implementation Plan (Hydrometrics 2000).

In November 2002, ASARCO entered into an Administrative Order on Consent (AOC) with the USFS for performance of an EE/CA for certain public lands within the UBMC. The AOC covers National Forest System lands along portions of Mike Horse Creek, Beartrap Creek (including the Mike Horse tailings impoundment) (Sections 20, 21, 27, and 28), and the Blackfoot River upstream of the confluence with Pass Creek (**Figure 1-1**) which may have been affected by operation of the Mike Horse Mine and tailings impoundment. The objective of the AOC was for ASARCO to develop removal action alternatives for evaluation through development of an EE/CA.

In 2003, DEQ brought legal action in State District Court against ASARCO and ARCO for recovery of DEQ's past and future remedial action costs associated with contamination and threats of contamination at the UBMC, and to require the companies to implement required remedial actions. As part of this action, DEQ also sought a declaratory judgment to establish liability for all future remedial action costs, including clean-up, which DEQ would incur in connection with the UBMC.

In 2005, ASARCO released a document entitled *Comprehensive Data Summary Report for the Upper Blackfoot Mining Complex, Lewis and Clark County, MT* (Hydrometrics 2005). The initial draft of the report was prepared as part of an interim settlement of the pending litigation. DEQ reviewed the draft report and provided comments to ASARCO and ARCO. DEQ's review of the resubmitted document (Hydrometrics 2005) indicated that the companies had not incorporated DEQ's comments adequately. Therefore, DEQ revoked the interim settlement agreement and completed the Comprehensive Data Summary Report itself with the assistance of its contractor, Tetra Tech EM, Inc.

In August of 2005, ASARCO filed for Chapter 11 bankruptcy. At the present time, DEQ's pending state court action continues to go forward concurrently with the bankruptcy.

In December of 2006, the BER revoked the temporary water quality standards due to failures and delays on the part of ASARCO in implementing the Temporary Water Quality Standards Implementation Plan. ASARCO continues to treat water from the Mike Horse and Anaconda mine adit discharges. These discharges are regulated under a MPDES permit.

In July of 2007, the USFS - Region 1 and ASARCO released an EE/CA concerning the clean-up of contaminants on USFS land at the UBMC entitled *Engineering Evaluation Cost Analysis for the Mike Horse Dam and Impounded Tailings, Lower Mike Horse Creek, Beartrap Creek and the Upper Blackfoot River Floodplain Removal Areas Upper Blackfoot Mining Complex, Lewis and Clark County, MT* (Hydrometrics 2007a). Also during July of 2007, the Helena National Forest, Lincoln Ranger District released an Action Memorandum based on the EE/CA (Helena National Forest 2007) selecting a preferred alternative for clean-up of the designated sub-areas. In brief, the Action Memorandum proposes: (1) total removal of the Mike Horse Dam and impounded tailing to an on-site in-drainage repository (Paymaster Repository); (2) complete removal of mine waste from Lower Mike Horse Creek and placing the waste into the Paymaster Repository; (3) removal of all concentrated and intermixed tailings from the active floodplain of Beartrap Creek and placing the waste into the Paymaster Repository; and (4) complete mine waste removal (estimated at 45,000 cubic yards) from the Upper Blackfoot River Sub-area and placement of the waste into the Paymaster Repository.

In 2007, DEQ contracted with Tetra Tech to complete a RI of the entire UBMC.

1.5 INDIVIDUAL MINE FACILITY OPERATIONAL HISTORY

The following summary of the operational history of individual mine facilities within the UBMC is taken largely from the DSR, which in turn came largely from the cultural resource inventory and evaluation report by GCM Services, Inc. of Butte (1993). Other information comes from a geologic report by McClernan (1983).

1.5.1 Anaconda Mine

The Anaconda Mine (**Figure 1-4**) was discovered and developed during the early 1900s by Gottfried Krueger. The mine workings are located on the Little Joe, Copper Bell, Blue Cristle, and Anaconda patented mining claims. The mine had no significant production until 1919, when 116 tons of ore were mined yielding approximately 72 ounces of gold, 2,629 ounces of silver, 10,865 pounds of copper, and 12,973 pounds of lead. The following four years, an average of about 25 tons of ore were taken from the Anaconda and processed in the mill at the Mike Horse Mine (GCM 1993).

Pardee and Schrader (1933) reported that by 1933 about 1,000 tons of ore had been produced from the Anaconda workings. There is no record of any subsequent production until 1939 when nearly 1,400 tons of ore were mined, producing 280 ounces of gold, 12,394 ounces of silver, 8,481 pounds of copper, and 14,600 pounds of lead. The following year, 50 tons of the mine's tailings were re-processed by the Giant Group Company of Helena who installed a 50 ton mill on the property. McClernan (1983) believes that total production from the Anaconda Mine was only about 1,660 tons of ore through 1948. This was apparently the last production from the mine although some development work was conducted in 1961 by the mine's owners, Paramount Estates of New York (GCM 1993).

The workings were developed to mine a discontinuous, northeast-trending, brecciated, fracture-filled vein that was from 3-5 feet thick along 75 feet of strike length, and occurred over a vertical distance of about 300 feet. The deposit contained galena, sphalerite, pyrite, bournite, arsenopyrite and rhodochrosite. The mine workings consisted of two shafts and two adits. The lower adit extended about 90 feet into the hillside and the nearby lower shaft was 325 feet deep. The upper adit was about 500 feet long (Pardee and Schrader 1933; McClernan 1983).

1.5.2 Carbonate Mine

The claims on the Carbonate Mine property (**Figure 1-4**) were staked in 1889 and the mine developed during the early 1900s. The property consists of four patented claims. Pardee and Schrader (1933) reported that the mine consisted of an adit which intersected the lode 106 feet from the portal, from which workings followed the vein about 750 feet to the northwest. Near the middle of the adit was a shaft which encountered the adit level about 100 feet below the surface and extended 200 feet below the adit level with the lower working level developed about 100 feet and 200 feet below the adit level. The deposit consisted of veins and pods of quartz–rich material in a shear zone that contain pyrite, galena, and sphalerite. During the 1930s, the property was controlled by the Glacier Mining Trust of Wilborn, Montana. The mine was reported to have had 875 feet of tunnels and 425 feet of shafts.

Beginning in 1947, the claims were operated by the New Silver Bell Mining Company. Reportedly, the property had 3,000 feet of drifts, 200 feet of shafts, and a 120-ton per day mill which processed the ore for gold, silver, copper, and lead. The mine was operated during the late 1940s until the mill burned down on August 8, 1949 and the mine was shut down (GCM 1993). No production figures exist for the Carbonate Mine, but McClernan (1983) surmises that the amount of drifting in the mine and the nearby tailings pond indicate that although some production probably did occur that it does not seem that the mine was a major commercial operation (GCM 1993). The claims were purchased by the Anaconda Company in 1967 and acquired by ASARCO in 1981.

1.5.3 Mike Horse Mine

The Mike Horse claim was first located by Joseph Heitmiller in 1898. Although development work on the property was undertaken for the next 15 years, little ore was shipped because there were no adequate roads to haul large amounts of ore to smelters. In 1915, the Sterling Mining and Milling Company of Ellensburg, Washington purchased the mine and production was resumed. Further production occurred in 1917, and in 1919 a new lode deposit was located. A mill was constructed at the mine and lead-silver concentrate was produced (the mill also processed ore from the nearby Anaconda and Paymaster mines). The mine operated during the 1920s with 1923 and 1924 being the most productive years of this decade when 1,120 tons of ore were processed. About three-quarters of the ore's value was in lead with the remaining one-quarter being silver.

The mine's underground workings consisted of a number of adits spaced over a vertical distance of about 300 feet. The adits and crosscuts intersect the Mike Horse, Little Nell, and Intermediate veins, and were connected by raises with several large stopes located within the workings. The mine reached a depth of about 450 feet (Pardee and Schrader 1933).

In 1938, the Mike Horse Mining and Milling Company leased the property and built a 150 tons-per-day flotation mill the following year. Electric power brought to the mine in 1940 operated throughout World War II. In 1941, a tailings impoundment was constructed across Beartrap Creek (upstream of the confluence with Mike Horse Creek) for disposal and containment of the floatation mill tailings from the Mike Horse Mill (Section 1.4.1). Prior to the construction of the floatation mill and tailings impoundment, it is presumed that the jig tailings were deposited directly on the ground or discharged to Mike Horse Creek. In 1945, ASARCO purchased the Mike Horse and operated it until 1955 when it closed due to declining metals prices. The mine was leased by the Rogers Mining Company of Helena in 1958, which operated the mine until early 1964 when the Anaconda Company of Butte acquired an assignment of the lease. The Anaconda Company began a large-scale project to evaluate a copper-molybdenum ore body in the Heddleston District (although no exploration is believed to have been conducted at the Mike Horse claims).

The Mike Horse was the mainstay of the Heddleston District, responsible for the bulk of the district's production. During the peak production period from 1941 to 1952, the mine consisted of 22,620 feet of drifts and crosscuts, and 660 feet of winzes. The usual work crew averaged 125 to 130 men who mined an average of about 200 tons of ore per day, which was processed in the flotation mill to produce a lead-zinc concentrate.

Mike Horse Tailings Impoundment

The Mike Horse Tailings Impoundment was constructed on the Beartrap Creek drainage in 1941 for disposal of tailings from the Mike Horse Mine floatation mill. All tailings produced from the Mike Horse Mine after this time were placed in the tailings impoundment. Prior to 1941, it is presumed that tailings (which would have been jig tailings) were deposited directly on the ground and/or discharged to Mike Horse Creek. Mining activities ceased at the UBMC by the mid-1950s.

In June 1975, heavy precipitation, along with blockage of a surface water diversion ditch by mudslide debris, caused the Mike Horse tailings impoundment to be breached. As a result, tailings were washed downstream and still persist along the Beartrap Creek and upper Blackfoot River floodplain. Several of the data collection programs discussed in this report focus on the effects of the tailings dam breach.

1.5.4 Paymaster Mine

The first work on the Paymaster Mine (**Figure 1-4**) property occurred in February of 1902 when a tunnel was reported to be under construction. In that same year, the Paymaster Gold Mining Company was incorporated and staked four claims (Black Diamond, Jumbo, Bonanza, and Cicero Lodes), which were patented in 1912. In 1912, improvements on the property included four discovery shafts, four tunnels, three drifts, and a winze.

Surface development apparently never went much beyond these initial improvements. When Pardee and Schrader (1933) examined the site in August of 1927, they reported the workings were partly closed by caving and it appeared they had not been worked for several years. The underground workings of the mines included a 900-foot long crosscut at the lowest adit, several hundred feet of drifts and a 50-foot winze. About 100 tons of ore were reportedly shipped from the mine.

The ore body in this area was particularly rich in molybdenum, and was also accessed by the Midnight and, later, the Edith mines. The Paymaster was re-opened in the 1960s through the established lower adit but no production was reported (McClernan 1983; Thompson 1989).

1.5.5 Outlying / Other Facilities

Edith Mine #2

The Edith Mine #2 (**Figure 1-4**) is a recent mining development within the Paymaster and Black Diamond ore veins. When the mining claims in this area were surveyed in 1904 (Mineral Survey No. 7353 and 7356) the plat map showed two discovery shafts, and two tunnels within the general vicinity of the Edith Mine. Nothing remains of these earlier features and there is no record of any production from this earlier operation. The ore body in this area was particularly rich in molybdenum and was exploited earlier by the Paymaster Mine located a quarter mile to the southwest and by the Midnight Mine located on the hill above the Edith.

The Edith Mine was re-opened by the Anaconda Company in 1967. A tunnel was driven north into the ore body from the base of the south-facing hillside. Samples of the ore proved to be high in molybdenum, but apparently no production was initiated by the Anaconda Company, and the operation was shut down a few years later.

Mary P Mine

A small mine called the Mary P Mine (**Figure 1-4**) was in operation in 1911. The mine was located a few hundred yards to the southeast of the Anaconda Mine on the opposite side of the Blackfoot River. The operation consisted of a discovery cut with a tunnel and a second tunnel with a short drift. There is no evidence of production from the Mary P and the mine was apparently closed down within a year or two (GCM 1993).

Midnight Mine

The Midnight Mine (**Figure 1-4**) was listed as shipping ore in May of 1904 while the Daylight Mine showed production even earlier in May of 1901. The two mines were part of the same operation of the Midnight Copper Mining Company which had driven a connecting tunnel and drifts through the Midnight, Copper Gate, and Daylight claims (patented in 1911). The 1915 plat map of the claims shows four discovery cuts, two shafts, two tunnels, three extensive drifts, and a “branch of tunnel” (GCM 1993).

By 1929, the Midnight was listed as having 3,000 feet of workings from several adits; however, during an idle period from 1926 to 1927, most of the old works had caved in. In 1929, work was underway on a new adit and 25 tons of copper and silver ore were shipped (Pardee and Schrader 1933; McClernan 1983).

Consolation Mines

Development on the property prior to 1933 consisted of several pits, three caved adits and a shaft about 20 feet deep (Pardee and Schrader 1933). Mineralization occurs as a thin vein of quartz-galena-pyrite and sphalerite adjacent to a porphyry dike in contact with the Spokane Shale.

Flosse and Louise Mining Claims

The Flosse and Louise mining claims claim (Mineral Survey No. 10465) are currently listed in the Lewis and Clark County records as owned by Mitchell and Joaquina Lovely of Helena, Montana. The claims are approximately 41 acres in size and the northern parts of the claims extend across Beartrap Creek north of the Mike Horse tailing impoundment (**Figure 1-4**). Small waste rock dumps are located on this claim within the Beartrap Creek channel bottom. McClernan (1983) reports a mine named the Red Wing located on the same 40 acre parcel of ground, and it is probable that the Red Wing Mine operated on the Flosse and Louise mining claims. McClernan reports that the Red Wing Mine has a 75 foot long adit that follows a near-vertical vein that trends southward. The vein has a reported thickness of 2 inches to 4 feet and consists of crushed and sericitized diorite rock with sphalerite, galena, and pyrite. No productions statistics were available or reported.

1.5.6 Other Facilities

A number of smaller mines and prospects (some with adits that discharge water) have recently been identified in the perimeter areas of the UBMC. Some of the mine wastes and adit discharges were sampled in 2007. Additional studies of these facilities are anticipated in 2008.

1.6 GENERAL SITE CHARACTERISTICS

1.6.1 Meteorology

Climatic conditions at the UBMC are typical of intermediate to high elevation regions of the Northern Rocky Mountains with long, cold winters and short, moderately hot summers. Based on climatic records from the National Oceanographic and Atmospheric Administration (NOAA) weather station at Rogers Pass (approximately two miles northeast of the UBMC), average monthly minimum and maximum temperatures recorded at the Rogers Pass Station average 13.4 °F in January, and 81.5 °F in July, respectively (**Table 1-2**). A record cold temperature of –70 °F was recorded on January 20, 1954 (Envirocon 1993).

Average monthly precipitation for the period of record ranges from 0.65 inches in February to 3.10 inches in June. Annual precipitation for the period is 17.99 inches, with the highest annual precipitation (31.4 inches) occurring in 1975 and the lowest annual precipitation (13.9 inches) occurring in 1988. The greatest one-day storm event recorded since 1964 occurred on June 19, 1975, resulting in 2.98 inches of precipitation (Envirocon 1993) and an embankment failure at the Mike Horse Tailing Impoundment.

Table 1-2
Monthly Climatic Data Summary from Rogers Pass NOAA Weather Station
8/21/64 to 9/30/04

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temp (°F)	33.1	38.4	44.1	53.7	63.0	71.4	81.5	80.5	69.3	57.9	41.9	34.3	55.8
Average Min. Temp (°F)	13.4	18.1	22.3	29.6	37.7	44.5	49.8	48.4	39.2	32.5	23.0	15.9	31.2
Average Total Precip (in.)	0.86	0.65	1.22	1.75	2.93	3.10	1.36	1.69	1.68	1.12	0.70	0.92	17.99
Average Total Snow Fall (in.)	13.1	11.7	15.3	11.5	4.2	0.0	0.0	0.0	2.6	4.2	8.6	13.8	85.1

Average climatic data from the Lincoln Ranger Station weather station located about 14 miles west of the UBMC are similar to that from the Rogers Pass Station. This indicates that weather patterns are relatively uniform throughout the UBMC and are reasonably well represented by the Rogers Pass data (Hydrometrics 2007b).

1.6.2 Vegetation

As reported in Western Technology and Engineering, Inc., (WTE 1993a), vegetation of the UBMC is typical of the northern Rocky Mountains, although it has been modified by mining and timber harvesting. Coniferous forest, dominated primarily by lodgepole pine, spruce and Douglas fir, covers mesic slopes above drainage bottoms. Field observation noted many of the dense stands of conifers exhibit impacts due to defoliating insects and mistletoe. Standing dead timber is common on the drier south-facing slopes. Drier slopes are interspersed with communities dominated by mountain big sagebrush and fescue grassland. Several riparian/wetland vegetation communities are present along streams and the floodplain of the Blackfoot River, including plant communities dominated by coniferous or deciduous tree species (quaking aspen and cottonwood species), shrubs or herbaceous species. Additional detail on the UBMC vegetation is available in the report prepared by WTE (1993a).

1.6.3 Wildlife

The ecology of the UBMC is diverse in terms of biological species. Portions of the UBMC are located in federally-designated grizzly bear and gray wolf recovery areas and bald eagles, peregrine falcons, and whooping cranes may sometimes enter the UBMC (WTE 1993b). The Blackfoot River is considered to be a substantial fisheries resource below USFS's Aspen Grove Campground (approximately 12 miles downstream of the Blackfoot headwaters), and the Montana Department of Fish, Wildlife and Parks (FWP) considers the UBMC to include viable trout and big game habitats. Genetically pure westslope cutthroat trout were found in Anaconda Creek above the Anaconda mine site (MFG 1996a). Westslope cutthroat trout, a species of special concern in Montana, has declined over much of its historic range within the last century. Field personnel during the 2007 fall investigation also noted observing one fish in each Anaconda Creek and the upper Blackfoot River.

Bull trout is a Montana species of special concern and threatened under the Endangered Species Act. The recovery of bull trout is a fisheries priority under both State FWP and Federal USFWS programs in the Blackfoot Watershed. Bull trout inhabit approximately 125 miles of the Blackfoot River main stem. Densities of bull trout are very low in the upper Blackfoot River, but increase downstream of the North Fork at river mile 54 (FWP 2005).

1.6.4 Soil

No National Resource Conservation Service soil survey has been completed for the UBMC, although the USFS has completed soil surveys for portions of the Facility (MFG 1996a). Two major soil units were identified in the UBMC, including Typic Cryoboralfs and Typic Cryoboralfs-

Typic Cryochrepts Complex. Both soil units consist of a mixed loamy skeletal soil with subsoil clay accumulations typically occurring 4 to 24 inches below the surface. Subsoils typically contain 40 to 60 percent angular rock fragments. The typical soil depth is approximately 40 to 60 inches over bedrock, although soils depths are variable over the UBMC. Typic Cryoboralfs are found over 25 to 50 percent of slopes, primarily on lower and midslope regions. The Typic Cryoboralfs-Typic Cryochrepts Complex are found on 40 to 60 percent of upper slope regions (MFG 1996a).

In the Wetlands Inventory of the Upper Blackfoot Project Area, Western Technologies and Engineering (1993a) describe the UBMC upland soils as being derived primarily from argillites, siltites and quartzites. Upland soils are medium-textured and consist of 40 to 80 percent angular rocks. Clay accumulations are common in subsoils. Drainage bottom soils are derived from stratified alluvial deposits. Soil textures are variable, and mostly range from silty loams to extremely gravelly, cobbly sandy loams.

In addition to the available site soils information summarized above, ASARCO has collected numerous soil samples from the UBMC as part of its reclamation planning and design activities. This sampling has focused on characterization of native soils to assess their suitability for use as vegetation growth medium in mine waste covers and revegetation of mine waste removal areas. Most soils are characterized as silty to sandy loam, with abundant (up to 50 percent) coarse fragments and less than 10 percent organic matter. Extensive soil characterization work has occurred in the Mike Horse, Paymaster, Anaconda and Edith mine areas, as well as at the Meadow Creek and Bartlett Creek soil borrow areas.

1.6.5 Demographics

The UBMC and surrounding area is sparsely populated and rural in character. According to the U.S. Census Bureau (http://factfinder.census.gov), the population density of the area is approximately one person per square mile. Based on an aerial photo survey, one residence is located along Beartrap Creek approximately 0.6 miles upstream of the Mike Horse Tailings Dam, and four residences are located within two miles downstream (west) of the confluence of the Blackfoot River and Pass Creek. The closest of these residences is located along US Highway 200 approximately 0.75 miles from the Blackfoot River/Pass Creek confluence. Lincoln, Montana, located along the Blackfoot River approximately 15 miles west of the Pass Creek/Blackfoot River confluence, is the closest population center. As of the 2000 census, Lincoln had a population of 1,100 (http://factfinder.census.gov).

A search of the Montana Department of Natural Resources and Conservation (DNRC) Groundwater Information Center (GWIC), revealed six private drinking water wells within a one-mile radius of the UBMC (one mile radius of the Mike Horse Tailings Dam, and one mile radius of the confluence of Blackfoot River and Pass Creek). All six wells are located west of the site in sections 18 and 19, with the closest well approximately 0.75 miles from the Blackfoot River/Pass Creek confluence and north of US Highway 200.

1.6.6 Land Use

Current Land Use

Facilities

Current land use at and in the vicinity of the UBMC is associated with past mining activities. Features include:

- Mike Horse Tailings Impoundment, including dam;
- Mike Horse Mine settling ponds (one shed is located at the ponds);
- Mike Horse Mine repository;
- Paymaster repository;
- Carbonate repository
- Beartrap Creek tailings;
- Anaconda Wetlands that treat Mike Horse and Anaconda adit acid mine drainage;
- State highway, county and USFS roads, local access roads;
- Various old degrading cabins and associated structures (i.e. sheds);
- Degraded wood buildings associated with Consolation Mine and Flosse-Louise Mine;
- Electrical and phone lines; and
- Various adits and shafts.

Work performed since the mid-1990s has include remedial actions to remove mining waste and treat metals contaminated water from the Mike Horse and Anaconda mine adits.

General Project Site

Land use in the project area is National Forest, private industrial forest, mining claims, conservation land, ranching, and to a small extent, residential. Management of National Forest System lands is guided by the Helena National Forest Plan (USFS 1986). Lewis and Clark County has developed a growth plan, which includes the Lincoln Planning Area Growth Policy (L&C County 2004). The Lincoln Planning Area Growth Policy sets guidelines for the protection of agricultural uses, rural lifestyle, and recreation.

There are no developed recreational sites within the project area. Dispersed recreation occurs throughout the area. Typical recreational uses may include hiking, camping, fishing, biking, motor biking, hunting, prospecting, and other similar uses. There is no known survey of actual site use in this area, although long-time observations by USFS personnel indicate that site use is largely recreational, with the highest site use occurring in the fall during big game hunting season (Hydrometrics 2007b).

US Highway 200 and the Mike Horse Creek Road (Lewis and Clark county road) provide general access to the area. Additional access is provided by local roads, USFS roads, and driveways.

The southwestern most portion of the project area contains both irrigated and non-irrigated prime farmland.

Future Land Use

Future land use within the UBMC is expected to be largely the same as current land use.

Management of the National Forest will continue to be directed by the Helena National Forest Plan. Information on plans for the future in the area is contained in the Lincoln Planning Area Growth Policy (L&C County 2004). For the UBMC, the growth plan sets forth policies to protect wildlife, recreation, and watershed values.

Land uses of private lands within the UBMC are not restricted by zoning or covenants at the present time. No significant development has occurred on private lands within the UBMC nor has any recent pattern of development evolved or become evident over time. There have been no recent building permits issued nor have any proposals for the subdivision of land been recently identified. Private lands have for the most part historically been used for mining activities, modest amounts of grazing, and recreation with or without the approval of the owners.

There are a large number of patented mining claims within the UBMC, most of which (41) are owned by ASARCO (see Section 1.4.2, and **Figure 1-3**), and have historically been used exclusively for mining and mined land reclamation purposes. Patented mining claims are principally associated with narrow historical vein-type deposits, most of which are difficult to mine using modern mechanized mining methods, and most of which are probably not currently economic to mine given the narrow mineralized structures.

In addition to patented mining claims, Asarco has historically held and continues to hold approximately 120 unpatented mining claims associated with a copper-molybdenum porphyry-type deposit within the UBMC. It is possible that this deposit could be proposed for mining in the future, with facilities sited on either patented or unpatented ground within the UBMC.

1.6.7 Regulated Sites

The review of regulated facilities was conducted in general accordance with Standard E 1527-05 issued by the American Society of Testing and Materials and conforms to the EPA's Standards and Practices for All Appropriate Inquiries - Final Rule published November 1, 2005. The purpose of this review is to identify existing regulatory and environmental conditions in connection with the UBMC or UBMC's individual mine sites. Records were obtained from EPA and DEQ on-line databases. The approximate minimum search distance (MSD) for the UBMC vicinity review is noted in the summary below.

A summary of the database information in the site vicinity appears in **Table 1-3**.

Federal Database Information

Federal NPL and Active CERCLIS List

There are no facilities within one mile of the UBMC on the National Priority List (NPL). The list was reviewed to identify Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) list was reviewed to identify facilities within one mile of the site. A review of federal databases indicated that the UBMC Facility is on the Active CERCLIS List. The UBMC Facility is shown with EPA ID #MTD986069474, has non-NPL status, and is designated a State-Lead Cleanup.

Table 1-3
Summary of Regulated Facilities in the Site Vicinity

MSD (Radius)	Data Source	Databases Searched	# of Facilities Identified
Federal Records			
1.0 mile	EPA NPL http://www.epa.gov/superfund/sites/cursites/	EPA Superfund Information System	0
0.5 mile	EPA Active CERCLIS List http://www.epa.gov/superfund/sites/cursites/	EPA Superfund Information System	1 – UBMC
0.5 mile	EPA CERCLIS and CERCLIS No Further Remedial Action Planned (NFRAP) http://www.epa.gov/enviro/	EPA's EnviroFacts (EnviroFacts)	0
1.0 mile	EPA RCRA facilities under Corrective Action (CORRACTS) http://www.epa.gov/enviro/	EnviroFacts	0
0.5 mile	EPA RCRA Non-CORRACTS for Treatment, Storage, and Disposal (TSD) facilities http://www.epa.gov/enviro/	EnviroFacts	0
0.25 mile	EPA RCRA database for Generator and Transporter Facilities http://www.epa.gov/enviro/	EnviroFacts	0
Property	Federal Institutional Control/Engineering Control Registry web sites http://www.epa.gov/swerffrr/documents/fi-icops_106.htm and http://www.epa.gov/superfund/action/ic/	EPA Institutional Controls and Federal Facilities Restoration and Reuse	0
Property	EPA Emergency Response Notification System (ERNS) http://www.nrc.uscg.mil/nrchp.html	National Response Center	0
State Databases			
1.0 mile	State Equivalent NPL http://nris.state.mt.us/	NRIS Remediation Response Sites list, MDEQ CECRA, Response Action, & CALA lists	1 – UBMC
1.0 mile	State Equivalent CERCLIS [MDEQ Comprehensive Environmental Cleanup and Responsibility Act (CECRA)] http://nris.state.mt.us/	NRIS Remediation Response Sites list, MDEQ CECRA, Response Action, & CALA lists	1 – UBMC
0.5 mile	State Voluntary Cleanup Program Sites [MDEQ Voluntary Cleanup and Redevelopment Act (VCRA) and Controlled Allocation of Liability Act (CALA) lists] http://nris.state.mt.us/	NRIS Remediation Response Sites	1

Table 1-3 Summary of Regulated Facilities in the Site Vicinity			
MSD (Radius)	**Data Source**	**Databases Searched**	**# of Facilities Identified**
Property	State Institutional Control/Engineering Control Registries http://www.deq.state.mt.us/StateSuperfund/vcra.asp	MDEQ CECRA, VCRA, Response Action Lists	0
0.5 mile	State MDEQ Brownfield Registry http://nris.state.mt.us/	NRIS Remediation Response Sites	0
0.5 mile	MDEQ Water Quality Act (WQA) database http://nris.state.mt.us/	NRIS Remediation Response Sites	0
0.5 mile	State Landfill and/or Solid Waste Disposal Facility List [MDEQ Solid Waste Registration (landfills)] http://nris.state.mt.us/	NRIS Remediation Response Sites	0
0.5 mile	State Leaking Underground Storage Tank (LUST) [MDEQ LUST List) http://nris.state.mt.us/	NRIS LUST list	0
0.25 mile	State Registered Storage Tank List [MDEQ Underground Storage Tank (UST) list] http://nris.state.mt.us/	NRIS UST list	0
Property	Abandoned Mine List http://nris.state.gov/deq/remsitequery/	NRIS Remediation Response Sites	1

State Database Information

Montana CECRA Listings

DEQ administers CECRA, which is the state equivalent to the EPA Superfund program. A review of state databases indicated that the UBMC Facility is an actively managed (high priority) CECRA facility.

Montana VCRA List (MSD = ½ mile)

DEQ administers the VCRA program for properties that are investigated and remediated at the initiation of the property owner, in accordance with DEQ requirements. The Paymaster Mine and No. 3 Tunnel of the UBMC is listed in the VCRA registry.

Montana Abandoned Mines

A listing of the Mike Horse Mine was found in the abandoned mine records from the Abandoned Mine Section, Remediation Division of DEQ.

Other Information

Not listed in the State of Montana database information are petroleum hydrocarbon reclamation activities at the Mike Horse Mine in the 1990s. These activities included the removal and off-site disposal of petroleum hydrocarbon-impacted soil and removal of a 1,000 gallon tank used for the storage of fuel.

Private and Commercial Water Supply Wells

Six private water supply wells are listed on the Montana Bureau of Mines and Geology, GWIC database in the vicinity of the UBMC. These are located in Sections 18 and 19, Township 5 North, Range 6 W. For these wells, the database indicated that static water levels ranged from 5 to 55 feet in depth and had a maximum yield of 60 gallons per minute. The approximate location of these water supply wells is shown on **Figure 1-5.** A summary of the GWIC database information for each of the six wells appears in **Table 1-4**.

Table 1-4
Summary of GWIC Database Information

GWIC ID	Site Name	Location	TD	SWL	Yield	Aquifer Lithology
143361	Cox, Armond & Esther	T15N R6W S18	55	20	20	S/G, red shale, gravel
71500	Romain, Vera #1	T15N R6W S19	25	5	60	Alluvium
71499	Romain, Vera #2	T15N R6W S19	25	5	20	Alluvium
71501	Bordeleau, Denis	T15N R6W S19	37	13	25	clay, rock, coarse S/G
237352	Zuelke, Bob & Kathleen	T15N R6W S19	58	7	15	shale, gravel
71502	Jankuit, E.G.	T15N R6W S19	65	55	6	Alluvium

Notes:
GWIC ID: MBMG Groundwater Information Center Identification No.
TD : Total depth of well in feet below ground surface
SWL : Static water level in feet below ground surface
Yield : Yield in gallons per minute
Aquifer Lithology : Type of rock and/or alluvial material that noted at and below measured water table
S/G : sand & gravel
Alluvium : alluvial material not defined

1.6.8 Current and Historical Aerial Photos

Tetra Tech is researching the availability of vintage photography.

1.7 SITE GEOLOGY

1.7.1 Regional Geology

In the area between Rogers Pass on the continental divide and the town of Lincoln, the Blackfoot River flows westward in a narrow valley parallel to US Highway 200. Along this stretch, the river has down-cut through a series of resistant bedrock ridges consisting of folded and thrust-faulted red, green and gray sedimentary mudstone units of the Precambrian Belt Formation. These units crop out in a geologic province called the southern Montana Overthrust Belt. The bedrock geologic units of the overthrust belt consist of a series of thick slabs of crustal rocks that have been sheared along low angle fault planes (thrust-faults) that moved the stacked (imbricate) slabs eastward over underlying rocks during the formation of the Rocky Mountains approximately 65 million years ago (Alt and Hyndman 1986).

In the Rogers Pass area, these Precambrian sedimentary units are cross-cut by small granite-like (quartz-monzonitic) intrusives that are several miles in diameter and approximately 35 million years old. A number of these intrusive bodies are associated with metallic ore deposits.

The Heddleston District, where the UBMC is located, is associated with one of these intrusive stocks. Mineralization in the Heddleston District occurs as two distinct types of deposits including:

1) a number of structurally controlled high-grade, copper-silver-lead-zinc vein-type mineralized fault and fracture structures that were mined from the turn of the century until the early 1950's; and

2) a large tonnage, lower-grade disseminated intrusive hosted (porphyry) deposit of copper-molybdenum mineralization that was never developed or brought into production.

The largest and most prominent mine in the Heddleston District was the Mike Horse Mine which occurred as vein-type mineralization associated with the Mike Horse Fault zone.

1.7.2 Site Geology

The geology of the UBMC is characterized by various bedrock units, with unconsolidated materials restricted to relatively thin accumulations of alluvium along drainage bottoms. Numerous reports have been published on the local and regional geology, including Miller (1973), McClave (1998), Pardee and Schrader (1933), Krohn and Weist (1977), and McClernan (1983). The following is a summary of the geology of the UBMC.

Unconsolidated Surficial Units

The Blackfoot River valley from the headwaters area near Rogers Pass eastward was occupied by a valley glacier during the last ice age. During still stands of the glacial front, a number of end moraines of glacial debris with associated outwash plains were deposited. The glacial end moraines form where the glacial front stands in one place, with glacial advances balanced by melting of the glacial front, such that the movement of the glacier acts like a conveyor belt moving debris to the front of the glacier. End moraine deposits take the form of sinuous cross-cutting ridges that cross the valley floor and are comprised of a very poorly-sorted mixture of boulders, gravel, sand, silt, and clay. These glacially deposited features result in a poorly-drained, hummocky, terrain of merged ridges alternating with intervening hollows or swales. In the Blackfoot River valley, glacial moraines locally act as dams with wetlands, marshes, and small lakes developed on the eastern, upstream side of the moraines. Outwash plains result from large flows of glacial melt water along the front of the glacier that tend to rework and redistribute previously deposited glacial valley floor sediments (ground moraines) out in front of the end moraines as large low angle fan or apron-like alluvial deposits that cover much of the valley floor (Alt and Hyndman 1986).

Unconsolidated deposits within the Blackfoot drainage of the UBMC consist of glacial end moraines and stream-reworked outwash materials in the valley bottoms, and colluvial slope-wash sediments on slopes transitional between ridge crests and valley bottoms. Alluvial sediments have been contaminated with mine wastes ranging from rather thick deposits of mine tailings with lateral and vertical continuity in the upper end of the drainage below the Mike Horse tailing dam, to inter-bedded alluvial and tailings deposits, to thinner over-bank deposits in downstream and marsh locations. Ridge crests and upper flanks of ridges tend to be covered with residual, weathered-in place soils.

Alluvial material thicknesses in groundwater monitoring wells in the UBMC range from 8 to 30 feet thick, and average about 18 feet. The shallower alluvial deposits occur at the upstream end of the valley near the Mike Horse Mine, and the thicker deposits occur near tributary stream junctions along the Blackfoot River. Unconsolidated material thickness in groundwater monitoring wells in the vicinity of the marshes and confluences of Porcupine and Meadow Creeks range from 22 to 42.5 feet thick , and average about 29 feet.

Bedrock Geologic Units

Three general bedrock units are found at the UBMC, including the Belt Series Spokane Formation, a diorite sill, and a series of Tertiary-age igneous intrusive bodies (**Figure 1-6**). The Precambrian Spokane Formation includes massive, light to dark gray quartzite and argillite at the bottom, grading upward to maroon to green argillite at the top (Miller 1973). The bedding planes dip from 5^0 to 30^0 north. The Spokane Formation is generally devoid of mineralization, except along margins of mineralized veins intruded into fractures within the argillite.

The Spokane metasedimentary rocks are intruded by a flat lying, diorite (gabbro) sill of Proterozoic age (McClave 1998). The sill is tabular in form and cuts across bedding planes of the Spokane Formation at a slight angle. The sill is well exposed in the northern two thirds of the area (upper Anaconda Creek and Shave Gulch drainages) where it reaches a thickness of 500 feet, but occurs primarily in the subsurface to the south (upper Mike Horse, Stevens, and Paymaster Creek drainages) where the thickness decreases to 200 feet due to vertical displacement by faulting. The top of the sill dips gently northward and strikes southwest-northeast. The diorite sill contains abundant chalcopyrite (copper-iron sulfide) and pyrite (iron sulfide), with the highest copper concentrations in soils within the Heddleston District occurring above sub-crops of the diorite as opposed to above mineralized veins or ore zones (McClave 1998).

A number of igneous intrusive stocks were emplaced within the older Spokane argillite and diorite sill in the central portion of the site (**Figure 1-6**). The igneous complex is quartz monzonite porphyry of Tertiary age. The quartz monzonite also forms linear dikes extending radially outward from the central stock, where molten rock intruded along faults and fracture zones within the country rock. Heat associated with the quartz porphyry at the time of emplacement caused hydrothermal solution to circulate through the country rock, producing the Heddleston District mineralization. The radial dikes extending outward from the central stock produced the mineralized veins first targeted for development in the district, including those at the Mike Horse, Anaconda, Paymaster, Carbonate, and other individual mines, while low grade, disseminated mineralization formed within the intrusive stock itself. Both the mineralized veins and zone of disseminated mineralization extend from south to north across the Blackfoot River drainage bottom (**Figure 1-6**).

Structure

Two principal fault systems have been identified at the UBMC including the Mike Horse fault system and the Blackfoot fault system (**Figure 1-6**). Both systems trend northwest-southeast, and predate emplacement of the porphyry intrusive. The Mike Horse fault system is the southern-most of the two, and extends from east of Mike Horse Creek drainage, westward through Paymaster Creek drainage. The mineralized veins exploited at the Mike Horse occur within subsidiary faults associated with the Mike Horse fault system. The second fault system (the Blackfoot Fault) is located approximately 4,000 feet to the north and trends subparallel to the Blackfoot River drainage bottom (**Figure 1-6**). Both of these fault systems exhibit vertical displacements on the order of 400 feet (Miller 1973). Numerous smaller northwest-trending structures occur within the UBMC, as well as older northeast trending structures. These structures control the localization of vein-type mineral emplacement, at several of the historic mines at the UBMC, including the Mike Horse, Anaconda, Paymaster and Carbonate.

Mineralization

Multiple episodes of bedrock mineralization/alteration have occurred at the UBMC, with all mineralization related to the Tertiary-age intrusive complex. Early mineralization includes a network of base and precious metal veins (characterized as quartz/pyrite/chalcopyrite veins), occurring within the porphyry intrusive body and extending radially outward. These radial veins, which are typically fault controlled with considerable bedrock fracturing along vein margins, were the targets of early mine development in the district. Examples include the northwest-southeast trending Mike Horse, Intermediate, and Little Nell veins, which were the targets of underground development at the Mike Horse Mine. All three vein structures dip steeply (approximately 75^0) south. Pardee and Schrader (1933) report that mineralized veins at the Mike Horse Mine average five feet in thickness.

Imprinted upon this fault-controlled vein mineralization and surrounding bedrock are localized, disseminated deposits of supergene enriched copper-molybdenum mineralization (the copper-moly ore zones). Two distinct copper-moly orebodies have been identified within the UBMC, including the “Number 3 Tunnel Ore Zone” located south of the Blackfoot River, and the “North Ore Zone” located north of the river (**Figure 1-6**). These two ore zones were the focus of an extensive mineral exploration program conducted by the Anaconda Company in the 1960s. A third ore zone has been identified a couple of miles south of the UBMC in Sandbar Creek drainage (McClave 1998).

Area Seismicity

The Intermountain Seismic Belt extends through western Montana, from the Flathead Lake region in the northwest corner of Montana to the Yellowstone National Park region where the borders of Montana, Idaho, and Wyoming meet. The Intermountain Seismic Belt continues southward through Yellowstone Park, along the Idaho-Wyoming border, through Utah, and into southern Nevada. In western Montana, the Intermountain Seismic Belt is up to 100 km wide. A branch of the Intermountain Seismic Belt extends west from the northwest corner of Yellowstone Park, through southwestern Montana, into central Idaho. This branch includes at least eight major, active faults and has been the site of the two largest known earthquakes in the northern Rocky Mountains, the August 18, 1959 Hebgen Lake, Montana, earthquake (magnitude 7.5), and the October 28, 1983 Borah Peak, Idaho, earthquake (magnitude 7.3). Small earthquakes are common in the region, occurring at an average rate of 7 to 10 earthquakes per day (http://mbmgquake.mtech.edu/montanaseismicity.html).

No work has been undertaken to establish recent movement on fault structures in the UBMC. Although, many of the high-angle faults shown on the UBMC geologic map (**Figure 3-1**) could be considered geologically active, most probably have very long recurrence intervals where the return period of seismic activity is on the order of thousands of years.

Based on information from the United States Geological Survey (USGS) earthquake database website (USGS 2007), approximately 116 earthquakes with a magnitude greater than 2.0 have occurred within a radius of 62 miles (100 km) of the UBMC between 1872 and 2007 (as of 10/29/07). Earthquake epicenters ranged in distance from 26 to 159 miles (16 to 99 kilometers) of the UMBC, with magnitudes from 2.0 to 6.25. From 1872 to 1972 the USGS kept records of only the largest earthquakes using various means of detection and estimates of magnitude. There were 19 earthquakes occurring from 38 to 159 miles (24 to 99 kilometers) of the UBMC with magnitudes ranging from 4.2 to 6.25 (average 5.0). The largest magnitude earthquake occurred 52 kilometers from the UBMC. Since 1972, the USGS has had better methods of detection and means of recording earthquakes. Ninety-seven earthquakes occurred within a 100 kilometer radius (16 to 99 km) of the UBMC ranging from 2.0 to 4.9 in magnitude (average 3.3). The closest recorded earthquake event was magnitude 3.4, about 16 kilometers from the UBMC.

The waste rock repository facilities and the Mike Horse Tailing Impoundment embankment are the only mine facilities on the UBMC that could be significantly affected by seismic events.

The Uniform Building Code foundation materials standards and USGS earthquake record data were used to assess seismic risk to the Mike Horse tailing dam facility. A seismic coefficient of 0.15g (g=acceleration of gravity) was used based on the a geotechnical report on the stability of the structure conducted by Dames and Moore (1975) that is summarized in the Data Summary Report (DEQ 2007). Earthquakes with a return-period of 50 years and 200-year period were assessed. The maximum credible earthquake used for the evaluation was a magnitude 6.0 occurring at distances of about 50 kilometers from the site. The probability of earthquakes occurring that have magnitudes capable of causing potential damage to the Mike Horse tailing facility are on the order of 2 percent for the 50 year and 11 percent for the 200-year return period. The Mike Horse tailing facility was drained of water late in the 2007 field season and is scheduled for removal by ASARCO during 2008-2009. There are no other facilities in the UBMC area that are likely to be significantly damaged by earthquakes with major impacts to resources.

1.8 SITE HYDROLOGY AND HYDROGEOLOGY

1.8.1 Surface Water

The drainage network in the UBMC is characterized by a dendritic pattern. Stream flow originates as snowmelt and as periodic rain events along steep upland slopes. Infiltration from these events provides base flow to streams throughout the remainder of the year. The major tributary streams in the UBMC include, from upstream to downstream, Beartrap Creek, Mike Horse Creek, Anaconda Creek, the Blackfoot River, Stevens Gulch, Shave (or Shaue) Creek, Paymaster Creek, Pass Creek, and Swamp Gulch (**Figures 1-1** and **1-2**). The Blackfoot River is formed by the confluence of Beartrap Creek and Anaconda Creek. Numerous tributaries of lesser significance join the Blackfoot River downstream of Swamp Gulch (**Figure 1-2**). Other significant surface water features include the Mike Horse Tailings Impoundment on Beartrap Creek (**Figures 1-1** and **1-2**) and a large marsh system, which begins near the confluence of the Blackfoot River and Pass Creek and extends several miles downstream. Physical and hydrologic characteristics for the streams listed above are shown in **Table 1-5**.

A floodplain analysis of the UBMC was completed as part of ASARCO's and ARCO's early site characterization program (Envirocon 1993). The study included stream cross-section surveys and bankfull width/elevation determinations at various locations on the Blackfoot River and tributaries. Peak flows at each point resulting from the 100-year storm event were also calculated using TR20 hydrologic modeling software. Bankfull elevations and peak flows from this study are included in **Table 1-5**.

The Mike Horse Tailings Impoundment is a 160 acre-feet capacity reservoir impounded by the Mike Horse Tailings Dam on Beartrap Creek and has been in existence since 1941. During normal flow periods on Beartrap Creek, water accumulates in the reservoir and is released as seepage through the earthen dam. During high stream flows resulting primarily from spring runoff and/or high-intensity spring storms (including rain on snow events), and during high standing levels of water in the impoundment (greater than 69 acre-feet) reservoir water discharges through an emergency overflow spillway pipe to Beartrap Creek via lower Mike Horse Creek (Hydrometrics 2007).

Table 1-5
Characteristics of Significant Streams in the UBMC

Stream	Drainage Area sq miles	Bankfull Elevation ft amsl[1]	Peak Flow from 100-yr Storm cfs[2]	Location	Range in Measured Flows 1991-2001 cfs[2]

Table 1-5
Characteristics of Significant Streams in the UBMC

Stream	Drainage Area sq miles	Bankfull Elevation ft amsl[1]	Peak Flow from 100-yr Storm cfs[2]	Location	Range in Measured Flows 1991-2001 cfs[2]
Mike Horse Creek	0.41	5556.8	214	Lower Mike Horse Creek	0.02 – 2.6
Beartrap Creek	2.02	5311.5	496	At mouth	0.005 – 10.4
Above Tailings Dam	1.42	--	--	--	--
Anaconda Creek	2.91	5346.6	726	At mouth	0.05 – 16.8
Stevens Gulch	0.56	5241.8	187	At mouth	0.006 – 2.0
Shave Gulch	3.28	5218.8	715	At mouth	0.042 – 16.8
Paymaster Creek	0.61	5230.1	193	Lower Paymaster Ck	0.041 – 5.1
Pass Creek	2.34	5194.8	416	At mouth	0.02 – 1.2
Swamp Gulch	0.26	5182.2	105	Lower Swamp Gulch	0.002 – 0.50

Source: DEQ 2007
Notes:
-- Not applicable
[1]Elevations and flows from Envirocon 1993.
[2]cfs-cubic feet per second

Beneficial Use

All surface waters within the UBMC are classified as B-1 waters (ARM 17.30.607) with the following identified beneficial uses (Water Quality Restoration Plan for Metals in the Blackfoot Headwaters TMDL Planning Area, DEQ June 2003):

- Growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers;
- Contact recreation;
- Agriculture water supply;
- Industry water supply; and,
- Drinking, culinary, and food purposes after conventional treatment.

The Blackfoot River (above Landers Fork), Beartrap Creek, and Mike Horse Creek are listed on Montana DEQ's 303(d) list as having impaired beneficial uses for aquatic life, cold water fish, and drinking water supply. Beneficial uses are identified as impaired due to the following pollutants of concern for the Blackfoot River and Beartrap Creek: cadmium, copper, iron, lead, manganese, and zinc; with the addition of aluminum for Mike Horse Creek. These pollutants are released from areas of historic mine activities and may also in part be related to natural background conditions.

Within the UBMC, 13 surface water right diversions are on file with priority dates ranging from 1892 to 1963 (**Table 1-6**). The purpose listed for all 13 rights is “mining”. Eleven of the water rights are owned by ASARCO, one by a private individual, and one by the USFS (for Mike Horse Dam).

1.8.2 Groundwater

Groundwater in the UBMC has been studied only in areas of known mining impacts, and predominantly along the stream valley bottoms. Thus a potentiometric surface map for the UBMC cannot be compiled at this time. Hydrogeology and groundwater quality is variable and appears to be site specific or locally controlled in many areas. However, the general pattern of groundwater flow is from higher elevation areas, where bedrock groundwater is recharged by snowmelt and spring storm events, towards the local drainage bottoms. Groundwater occurs within fractured metasediments, igneous bedrock units, and within unconsolidated alluvium in drainage bottoms. Bedrock groundwater discharges to local stream drainages, recharging the alluvial groundwater system and ultimately sustaining base flow in local streams during periods of low precipitation. The recharge area of the UBMC watershed is relatively small, due to topography and close proximity to the Continental Divide and; therefore, annual precipitation amounts and timing significantly influence base flows in area streams.

Based on invariably low yields (a few gpm or less) from bedrock monitoring wells at the UBMC, bedrock permeability is considered to be low with groundwater flow occurring predominantly through secondary fractures, joints, and fault zones. This conclusion is supported by relatively low base flow discharge (typically less than 25 gpm) from the Mike Horse Mine adit despite workings that include more than 30,000 lineal feet of tunnels, drifts, raises, and winzes (MSE 1997). Alluvium has a much higher permeability than bedrock due to the predominance of gravel and cobbles in the larger UBMC drainages (Beartrap Creek, Anaconda Creek, and the upper Blackfoot River).

Beneficial Use

Four groundwater rights are on record in the vicinity of the UBMC (**Table 1-7**). All are located outside of the UBMC and upgradient of groundwater or surface water exiting the Facility. The nearest groundwater right listing to the UBMC is within Porcupine Gulch (downstream of Swamp Gulch) and is owned by the USFS for domestic use.

A total of 13 wells are on record with the State of Montana in the vicinity of the UBMC. Seven of the monitoring wells are on record within the Facility and the remaining six wells are all within one mile downstream of the UBMC with a purpose listed as either domestic or commercial use.

Because there is limited groundwater data at the Facility, the groundwater has not been classified. Data necessary to classify the groundwater will be obtained during the RI.

Table 1-6
Surface Water Rights

Owner	Water Right Number	Well Location			Water Right Type	Year	Purpose
		Township and Range	Section	Quarter Section			
USFS	76F 52008 00	15N 6W	27	SESWNW	Statement Of Claim	1930	Mining
ASARCO Inc	76F 97609 00	15N 6W	28	NWNESE	Statement Of Claim	1916	Mining
ASARCO Inc	76F 97610 00	15N 6W	28	NWNESE	Statement Of Claim	1919	Mining
ASARCO Inc	76F 97611 00	15N 6W	28	NWNESE	Statement Of Claim	1941	Mining
ASARCO Inc	76F 97612 00	15N 6W	28	NWNESE	Statement Of Claim	1941	Mining
ASARCO Inc	76F 97613 00	15N 6W	20	S2NE	Statement Of Claim	1892	Mining
ASARCO Inc	76F 97614 00	15N 6W	20	S2NE	Statement Of Claim	1895	Mining
ASARCO Inc	76F 97615 00	15N 6W	28	NWNESE	Statement Of Claim	1945	Mining
ASARCO Inc	76F 97616 00	15N 6W	28	NWNESE	Statement Of Claim	1945	Mining
ASARCO Inc	76F 97622 00	15N 6W	21	SWNWNE	Statement Of Claim	1963	Mining
ASARCO Inc	76F 97623 00	15N 6W	20	SENWSE	Statement Of Claim	1902	Mining
Cartan, Gloria J,	76F 97850 00	15N 6W	16	NW	Statement Of Claim	1916	Mining
	76F 97850 00	15N 6W	16	SW			
	76F 97850 00	15N 6W	17	E2E2SE			
ASARCO Inc	76F 98318 00	15N 6W	20	SWSENW	Statement Of Claim	1943	Mining

Table 1-7
Water Wells and Ground Water Rights in UBMC Vicinity

Well Location				Well Depth (ft)	Depth to Surface Water (ft)	Year	Owner	Water Right Type	Water Right Number
Quarter Section	Section	Township	Range						
SE¼ SE¼	18	15N	06W	55	20	1994	Cox, Amond B	Ground Water Certificate	91569-00
SE¼ SE¼	18	15N	06W	55	20	1994	Cox, Gail	Ground Water Certificate	91569-00
NE¼ SE¼ SE¼	19	15N	06W	--	--	1959	USA (Dept of Agriculture Forest Service)	Statement of Claim	52005-00
NW¼ NW¼ NE¼	19	15N	06W	--	--	1959	Zuelke, Kathleen J	Statement of Claim	116746-00
NW¼ NW¼ NE¼	19	15N	06W	--	--	1959	Zuelke, Robert E	Statement of Claim	116746-00
SE¼ SE¼ NE¼	19	15N	06W	37	13	1982	Bordeleau, Denis	Ground Water Certificate	42722-00
SE¼ SW¼ SE¼	31	15N	07W	280	100	1992	Phelps Dodge Mining Co	Ground Water Certificate	82233-00
SE¼ SW¼ SE¼	31	15N	07W	1175	--	1997	Seven-Up Pete Joint Venture	Ground Water Certificate	101832-00

Figure 1-1 Location Map
Figure 1-2 Existing Conditions
Figure 1-3 Land Ownership
Figure 1-4 Historic Mining Features
Figure 1-5 Regulated Facilities
Figure 1-6 Geologic Map of the UBMC

2.0 SUMMARY OF HISTORICAL RECLAMATION ACTIVITIES

In 1993, ASARCO and ARCO began a reclamation program to address environmental impacts from historic mining activities at the UBMC. It is relevant to note that these activities were conducted without DEQ approval and some of the work may not meet the CECRA cleanup criteria in § 75-10-721, Montana Code Annotated (MCA). Accumulations of mine waste, including mine waste rock and tailings from historic mining activities, were identified in portions of the UBMC. Several mine waste piles were located in drainage bottoms resulting in potential metals leaching to surface water. Beginning in 1993, mine waste piles associated with the Carbonate, Anaconda, Edith, and Paymaster mines were removed and placed in engineered repositories (**Figure 2-1**) to limit potential leaching and subsequent mobilization of metals to waters of the State. In all, approximately 100,000 yd^3 of mine waste were either removed from drainage bottoms and isolated in three on-site engineered repositories, or reclaimed in place. In addition to mine waste removal, ASARCO and ARCO constructed a passive water treatment system in 1996 to treat drainage from the Mike Horse adit as well as the combined discharges from an adit and shaft at the Anaconda Mine. The following is a discussion of past reclamation activities at the UBMC.

2.1 PREVIOUS INTERIM ACTIONS (1993-1998)

The following is a site-by-site review of reclamation activities completed by ASARCO and ARCO as part of the UBMC reclamation program. **Figure 2-1** provides an overview may showing mine waste and mine waste removal and reclamation areas in the UBMC. **Figure 2-1a** through **Figure 2-1f** are detail maps showing each of these areas. These maps are provided at the end of this section. DEQ provided review and comment on the project work plans and reports but did not approve any of the work. Reclamation activities were also coordinated with several other land management and regulatory agencies through project review and/or permitting. The USFS provided review of remedial design plans and approval of a Plan of Operations to allow access to National Forest System lands during reclamation activities. Environmental and/or construction permits also were obtained from the U.S. Army Corps of Engineers (Section 404 permits), the Lewis and Clark County Conservation District (Section 310 permits), and DEQ (MPDES permits, Section 3A permits and storm water discharge permits).

The following is a site-by-site chronology of reclamation activities completed between 1993 and 1998.

2.1.1 Anaconda Mine

The Anaconda Mine is located at the headwaters of the Blackfoot River adjacent to the confluence of Anaconda Creek and Beartrap Creek (**Figure 1-1**). Approximately 38,800 yds^3 of mine waste was removed from the Anaconda Mine in 1995 and 1996 and placed in the Mike Horse Repository (Hydrometrics 1996b). Most of the removed mine waste was originally located on the floodplain of the Blackfoot River resulting in potential leaching of metals, and erosion and transport of mine waste to the river.

Two additional mine waste piles located on a hillside adjacent to the Anaconda Mine were also reclaimed in 1996. Because of their distance from any surface water drainage, these piles were reclaimed in-place, by amending with cement kiln dust, regrading, covering with growth medium, and applying a seed/mulch mixture. Water quality improvements in the upper Blackfoot River, due in part to the Anaconda Mine reclamation, are shown in **Table 2-1**.

In addition, the following remediation features were constructed: a concrete/bentonite plug was placed in the collar of the Anaconda shaft, a permanent vehicle crossing, surface water run-on control ditches with rip-rap, and fencing.

Table 2-1
Upper Blackfoot River Pre-Reclamation and Post-Reclamation Water Quality

	Parameter								
	pH	**Al (D)**	**As (T)**	**Cd (T)**	**Cu (T)**	**Fe (T)**	**Pb (T)**	**Mn (T)**	**Zn (T)**
DEQ-7 HHS	A	N/A	0.01	0.005	1.3	0.3**	0.015	0.05**	2
DEQ-7 ALS	B	0.087***	0.15	0.000097*	0.00285*	1	0.000545*	N/A	0.037*
Site BRSW-9									
Pre-Reclamation Range (1991-1996)									
Minimum	6.9	<0.05	<0.002	0.003	0.013	<0.03	0.005	0.35	0.978
Maximum	8.1	0.209	<0.02	0.012	0.18	13.6	0.035	2.1	4.4
Post-Reclamation Range (1999-2004)									
Minimum	6.4	<0.05	<0.002	<0.0027	0.006	0.04	<0.003	0.16	0.4
Maximum	8.1	0.065	<0.005	0.0155	0.19	0.62	0.044	3.8	3.45
Site BRSW-12									
Pre-Reclamation Range (1991-1996)									
Minimum	7.2	<0.05	<0.002	0.002	0.008	0.042	<0.003	0.2	0.72
Maximum	8.0	0.317	<0.008	<0.01	0.06	0.507	0.073	0.96	2.5
Post-Reclamation Range (1999-2004)									
Minimum	6.2	<0.05	<0.002	<0.001	0.007	<0.02	<0.003	0.1	0.48
Maximum	7.8	0.13	<0.005	0.006	0.08	0.33	0.018	0.6	1.7

Notes: Al-Aluminum; As-Arsenic; Cd-Cadmium; Cu-Copper; Fe-Iron; Pb-Lead; Mn-Manganese, Zn-Zinc.
D=dissolved, T=total or total recoverable.
Metals and arsenic concentrations are mg/L; pH is field-measured in standard units.
½ the detection limit was used for “non-detects” to calculate averages.
Sampling locations shown in **Figure 3-6**.
Surface water standards are based on total recoverable metals, except aluminum (dissolved).
DEQ-7 HHS = Human Health Standards for surface water from Circular DEQ-7.
DEQ-7 ALS = Aquatic Life Standards (chronic standard) for surface water from Circular DEQ-7.
* = value based on 25 mg/L hardness – actual hardness not calculated; used for comparison purposes only
** = value provided is based on secondary maximum contaminant limits and is included in Circular DEQ-7.
*** = Aluminum standard is for pH range 6.5 - 9.0 only.
A = Narrative standard provided in ARM.
B = Standard based upon water use classification, see ARM.
N/A = no standard or guidance value is provided in DEQ-7.

In 1996, a passive wetlands-based water treatment system was built at the former location of the Anaconda mine waste adjacent to the confluence of Anaconda Creek and Blackfoot River. A plug with piping and controls was installed in the Anaconda adit, with the water discharge to the water treatment system. As discussed in Section 2.1.4, this system treats discharge waters from the historic Mike Horse and Anaconda adits and is permitted and regulated under the MPDES program.

2.1.2 Carbonate Mine

Voluntary cleanup at the Carbonate Mine began the summer of 1993 and was completed in 1994. Unless noted, the following information was taken from the Activities Reports for 1993 and 1994 (Hydrometrics 1994 and 1995a) and the Identification of Remedial Action and Work Plan for Implementation of Remedial Action (MFG 1993).

The following construction work was completed during 1993 and 1994a:

- 43 and ¾ cubic yards of concrete were poured into and on top of an open mine shaft at the Carbonate Mine (Hydrometrics 1994).
- A surface water diversion ditch lined with rip rap was installed above the repository location.
- Approximately 15,400 cubic yards of waste rock and tailings were removed from Swamp Gulch drainage (lower Carbonate mine area) and placed in a repository constructed at the upper Carbonate (material was compacted with a sheep’s foot roller).
- Quicklime (1,500 tons) was added to the mine waste deposited at the upper Carbonate repository (Hydrometrics 1994).
- The repository slope was covered with a 6-inch layer of drainage gravel (except for the north slope) overlain by 12 to 18 inches of cover soil. The north slope received a 12-inch cover soil only.
- The flat portion of the repository was covered with gravel, a geosynthetic clay liner and cover soil. The thicknesses of these materials are unknown.
- Contaminated water from the pond created when the lower Carbonate Mine waste was removed was pumped to the repository and fill material was placed in the excavated hole. The Work Plan specified that a 2-inch layer of crushed limestone would be placed over the fill material to minimize acid generation potential.
- The former tailings impoundment area was backfilled with borrow gravel and cover soil (13 to 17 inches deep (Construction Reports: 9/13/94 and 9/26/94), and the area graded to establish a wetland and meadow within Swamp Gulch drainage.
- The repository, wetlands and other disturbed areas were revegetated.
- Groundwater monitoring wells were installed at the repository.

- Final grading was completed and storm water control ditches and structures were constructed.

In 1995, the repository cap cover was compromised due to erosion. Consequently, the growth medium soil was replaced, an erosion mat placed, and the area seeded and mulched during the 1995 construction season (Hydrometrics 1996b).

Water quality in Swamp Gulch, a perennial tributary to the Blackfoot River draining the Carbonate Mine area, has improved significantly as a result of the Carbonate Mine reclamation (**Table 2-2**). However, further evaluation of the water quality in Swamp Gulch is warranted to determine current concentrations of metals that may exceed DEQ-7 Standards. Data are provided in the Data Summary Reports (Hydrometrics 1995, 1996, 1997, 1998).

Table 2-2
Pre-Reclamation and Post-Reclamation Water Quality in Swamp Gulch Downstream of the Carbonate Mine

	Parameter								
	pH	Al (D)	As (T)	Cd (T)	Cu (T)	Fe (T)	Pb (T)	Mn (T)	Zn (T)
DEQ-7 HHS	A	N/A	0.01	0.005	1.3	0.3**	0.015	0.05**	2
DEQ-7 ALS	B	0.087***	0.15	0.000097*	0.00285*	1	0.000545*	N/A	0.037*
Pre-Reclamation Range (1991-1994)									
Minimum	2.6	<0.05	<0.002	<0.001	0.016	0.581	<0.005	0.323	0.145
Maximum	7.3	0.16	<0.02	0.042	1.35	64.7	0.253	6.8	3.73
Post-Reclamation Range (1995-1998)									
Minimum	7.5	<0.05	<0.002	<0.001	<0.005	0.054	<0.003	0.06	0.01
Maximum	8.0	<0.1	<0.005	<0.001	0.01	1.3	<0.01	0.33	0.065

Notes: Al-Aluminum; As-Arsenic; Cd-Cadmium; Cu-Copper; Fe-Iron; Pb-Lead; Mn-Manganese, Zn-Zinc.
D=dissolved, T=total or total recoverable.
Metals and arsenic concentrations are mg/L; pH is field-measured in standard units.
½ the detection limit was used for "non-detects" to calculate averages.
Sampling location BRSW-15 shown on Exhibit 1.
Surface water standards are based on total recoverable metals, except aluminum (dissolved).
DEQ-7 HHS = Human Health Standards for surface water from Circular DEQ-7.
DEQ-7 ALS = Aquatic Life Standards (chronic standard) for surface water from Circular DEQ-7.
* = value based on 25 mg/L hardness – actual hardness not calculated; used for comparison purposes only
** = value provided is based on secondary maximum contaminant limits and is included in Circular DEQ-7.
*** = Aluminum standard is for pH range 6.5 - 9.0 only.
A = Narrative standard provided in ARM.
B = Standard based upon water use classification, see ARM.
N/A = no standard or guidance value is provided in DEQ-7.

2.1.3 Edith Mine

The Edith Mine is located along the Blackfoot River near its confluence with Shave Gulch (**Figure 1-1**). Approximately 5,000 cubic yards of mine waste were removed from the Edith Mine in 1995 and placed in the Mike Horse Repository (Hydrometrics 1996b). Mine waste removal areas were amended with lime material to neutralize soil acidity, and the area was seeded to promote vegetation establishment.

2.1.4 Mike Horse Mine

Reclamation activities completed at the Mike Horse Mine include excavation of mine waste and construction of a repository at the lower Mike Horse Mine in 1995 and 1996, and in-place reclamation of approximately five acres of disturbed land at the upper Mike Horse Mine in 1998 (Hydrometrics 1997b, 1998b). The Mike Horse Repository was built to accommodate mine waste mainly from the Anaconda and Edith mines, as well as a relatively small volume of mine waste from the lower Mike Horse Mine.

Construction of the Mike Horse Repository included a subsurface shallow groundwater collection and drainage system to maintain groundwater levels below the repository base, a limestone gravel drainage layer beneath the repository, amendment of the upper 18 inches of mine waste in the repository to limit long-term acid generation, a 12-inch growth medium layer on the repository slopes with vegetative cover, and a geosynthetic clay liner on the upper, flat repository crest (Hydrometrics 1995b). Approximately 45,000 cubic yards of mine waste from the Mike Horse, Anaconda, and Edith mines were placed in the Mike Horse Repository (Hydrometrics 1996b). In addition, a sludge drying bed for the pretreatment pond sediment was constructed on the top of the repository (Hydrometrics 1996b). An as-built drawing is included in the 1995 Activities Report (Hydrometrics 1996b).

Land disturbance at the upper Mike Horse Mine consisted of waste rock piles spread over steep hillsides. Reclamation included consolidation and regrading of mine waste to minimize surface area and limit infiltration, incorporating amendments into the mine waste to raise pH and immobilize metals, placement of local borrow soil over the mine waste, construction of ditches and berms to divert storm water runoff around mine waste areas, and seeding of all disturbed areas. Regrading of the mine waste piles and establishment of a vegetative cover was intended to reduce infiltration of rainfall and snowmelt water, and erosion of mine waste, thus improving water quality in adjacent Mike Horse Creek. Revegetation at the reclaimed Mike Horse waste rock pile sites has not been re-established to the desired density. Species present in the reclamation areas appear to be limited in diversity, are not robust, and some portions of these areas are essentially denuded. As a result of these observations samples were collected in 2007 from the waste rock pile reclamation surfaces to determine the reasons for the poor revegetation response. This initial round of sampling may identify additional data gaps for 2008 sampling efforts that examine revegetation density and diversity, and soil characteristics such as acidity, and nutrient and organic carbon content.

Additional reclamation activities at the Mike Horse Mine included removal and off-site disposal of hydrocarbon contaminated soil, removal of a 1000-gallon tank, removal of waste rock and debris from Mike Horse Creek, reconstruction of the Mike Horse Creek channel through the reclaimed area, construction of a surface water diversion system to divert Mike Horse Creek water around the disturbed area, and construction of a pond and filtration system for treatment of the Mike Horse Adit discharge water. The pond and filtration treatment area has been fenced and signs have been installed (Hydrometrics 1997b).

Mike Horse/Anaconda Passive Wetland Treatment System

A number of studies in the Blackfoot River drainage have documented discharge from the Mike Horse Mine Adit as a significant source of metals loading to the upper Blackfoot River. ASARCO constructed a water treatment system to treat drainage from the Mike Horse Adit, as well as the combined discharges from an adit and shaft at the Anaconda Mine near the confluence of the Blackfoot River and Anaconda Creek. The system was installed at this location (**Figure 2-1 and Figure 2-1c and 2-1e**). The system is constructed on the site of Anaconda mine waste near the confluence of the Blackfoot River and Anaconda Creek. The system was installed at this location following mine waste removal. This system was completed and went on-line in October 1996. Key considerations in the design and operation of this system were: (1) availability of land under appropriate ownership and suitable for treatment system construction; (2) the lack of infrastructure (e.g. electrical power) within the UBMC; and, (3) maintenance of the rural and undeveloped nature of the area. Original plans included a second phase of wetland cells to be built on National Forest System lands and to operate in series with the existing wetland treatment system, thus doubling the treatment system capacity. However, efforts by ASARCO to negotiate a property exchange with the USFS for the needed land were unsuccessful and ASARCO chose to complete the undersized system. To compensate for the smaller wetlands area, ASARCO began adding a soluble organic carbon source (methanol) to the wetland system in 1999. The organic carbon is drip-fed into the upper anaerobic cell at a rate of 18 millimeters per minute, with carbon addition continuing to the present.

Components of the treatment system include a 600,000 gallon oxidation/settling pond and a sand filter bed at the Mike Horse Mine for removal of iron from the Mike Horse Adit discharge, an open limestone channel at the Anaconda Mine for iron removal and alkalinity generation in the Anaconda Adit/Shaft discharge, and a multi-cell constructed wetland water treatment system located at the Anaconda Mine and designed to remove metals from the combined Mike Horse Adit and Anaconda Adit discharges through sulfide generation. In addition, both the Mike Horse and Anaconda adits were fitted with flow-through concrete bulkhead plugs in 1995 to regulate seasonal flows and to partially flood the mine workings. Flooding of the mine workings is intended to improve the quality of the adit discharge water by reducing oxygen availability to the mine workings. This is accomplished by forcing oxygen to diffuse at a greatly reduced rate, through the water contained in the flooded workings, where available oxygen is rapidly consumed by limited pyrite oxidation. The resulting chemically reduced groundwater of the mine significantly limits the rate of sulfide mineral oxidation.

The constructed wetland water treatment system is designed to passively remove trace metals from the Mike Horse Mine and Anaconda Mine adit discharges. The anaerobic (low oxygen) environment within the wetland cells subsurface promotes conversion of sulfate to sulfide. The sulfides then complex with metals and metal-sulfide minerals precipitate out of the water. The sulfate reduction process is catalyzed by sulfate-reducing bacteria that reside within the wetlands' gravel substrate. The specially adapted wetlands plants (Carex) provide both a food source for the sulfate-reducing bacteria (dissolved organic carbon), and a biofilm (root structure) to support the bacterial community and accompanying sulfate reduction. The wetland system has a total treatment area (internal to the wetland berms) of 2.25 acres, distributed as follows: Cell A - 0.3 acres, Cell 4 - 0.8 acres, Cell 5 - 0.6 acres, and Cell 6 - 0.55 acres. Details of the treatment system design are included in MFG 1994b, 1994c and 1996. Construction details are presented in Hydrometrics 1997b. Discharge from the treatment system is at the west end of the constructed wetlands and enters the Blackfoot River. The discharge is permitted under the MPDES program.

Water Treatment System Performance

In order to evaluate performance of the UBMC mine water treatment system, water samples of the Mike Horse Adit discharge and the constructed wetland treatment system discharge were collected on an approximately monthly basis from November 1996 through July 2001. Metals removal rates through the treatment system (oxidation/settling pond and constructed wetlands system) for the monitoring period varied both on an element-specific and a seasonal basis. Metals removal rates in excess of 90 percent are typically achieved for most metals during summer months when water temperatures and wetlands biological activity are highest. Treatment efficiencies tend to decrease in the winter in response to depressed water temperatures and biological metabolism. Average monthly metals removal rates for the monitoring period were: iron-99.7 percent, lead-96.7 percent, copper-84 percent, cadmium-83 percent and zinc-67.5 percent. Zinc removal rates are less than those for other metals due to the relatively high stability of zinc as a soluble and mobile ion under typical water chemistry conditions. Observed monthly reductions in metals concentrations achieved through the water treatment system are shown in Table 2-3 of the Data Summary Report (DEQ 2007).

Treatment of the Mike Horse and Anaconda adits discharge waters through the constructed wetlands treatment system has reduced the load, or mass, of metals entering the upper Blackfoot River (see Figure 2-6 of the DSR (DEQ 2007). Loads of copper, cadmium, lead and iron have decreased by approximately 99 percent as a result of construction and operation of the water treatment system. Zinc loading from the Mike Horse and Anaconda adits to the Blackfoot River has decreased by more than 70 percent, from an average of 45 pounds per day prior to treatment, to an average of 12.5 pounds per day since the water treatment system was brought on line. The metal load reductions result from decreased metals concentrations and flow rates from the adits (due to flooding of the mine workings) as well as metals removal through the treatment. Therefore, the overall metal load reductions are greater than the reductions in metal concentrations achieved through the treatment system alone. Nevertheless, the wetlands treatment system discharge, as it presently operates, represents a source of metals loading to the Blackfoot River as reported in the Water Quality Restoration Plan for

Metals in the Blackfoot Headwaters TMDL Planning Area (DEQ 2003). The current concentrations of some metals in the system's effluent do not meet water quality standards.

Operational problems have occurred at the wetlands system over the past couple of years due to plugging of some of the subsurface plumbing, and possibly portions of the Cell 4 substrate. This has resulted in surface flow conditions at Cell 4, as opposed to the designed subsurface flow, anaerobic condition intended for Cell 4. Due to the aerobic conditions, increasing the methanol feed rate would not improve treatment efficiency. ASARCO initiated maintenance repairs at Cell 4 in 2005, including unplugging of piping at Cell 4. This work was completed in 2006.

ASARCO is currently in the design phase of moving from the semi-passive wetlands system to a long-term active treatment system to treat the Mike Horse and Anaconda adit discharge.

Mike Horse Mine Soil Hydrocarbon Removal

Additional reclamation activities at the Mike Horse Mine included removal and off-site disposal of hydrocarbon contaminated soil, removal of a 1,000 gallon tank, removal of waste rock and debris from Mike Horse Creek, reconstruction of the Mike Horse Creek channel through the reclaimed area, construction of a surface water diversion system to divert Mike Horse Creek water around the disturbed area, and construction of a pond and filtration system for treatment of the Mike Horse Adit discharge water. The pond and filtration system has been fenced and signs have been installed (Hydrometrics 1997b).

2.1.5 Paymaster Mine

Waste rock removal was implemented at the Paymaster Mine and Tunnel #3 areas in 1996 (**Figure 2-1, Figures 2-1a**, and **Figure 2-1b**). The Paymaster Mine was a relatively small operation which mined ore from three adits in lower Paymaster Creek drainage. No. 3 Tunnel was a bulk sample adit driven by the Anaconda Company for exploration of the south copper-molybdenum ore zone. Three distinct waste rock piles, totaling approximately 8,065 cubic yards, were removed from the Paymaster Creek drainage bottom, and an additional 4,955 cubic yards of mine waste was removed from the Tunnel #3 area. All material was fully amended with cement kiln dust to neutralize acidity and immobilize metals, and placed in an engineered repository located near the Paymaster Mine (Hydrometrics 1997b and 1998b).

In addition to the Paymaster Mine and No. 3 Tunnel mine wastes, approximately 8,412 cubic yards of mine tailings from a DEQ abandoned mine reclamation project was placed in the Paymaster Repository. The Big Blackfoot tailings were transported from their location approximately 25 miles west of the UBMC and placed in the Paymaster Repository by DEQ with permission from ASARCO and ARCO. All material placed in the Paymaster Repository was fully amended with lime products to neutralize the mine waste. The repository was designed for possible expansion in the future to accommodate additional mine waste, if necessary.

Remediation at the Paymaster Mine also included collection of a small volume of seasonal discharge from the historic Paymaster adit and treatment through a passive wetland treatment cell. Discharge from the Paymaster adit water treatment system was regulated under a MGWPCS permit. The passive wetland treatment system is no longer in operation and the permit was abandoned by Asarco.

2.1.6 Capital Mine

The Capital Mine is a relatively small mine located in upper Stevens Gulch (**Figure 2-1 and 2-1c**) on patented mining claims that were reclaimed by ASARCO in 1997 (Hydrometrics 1998b).

Reclamation at the Capital Mine included removal of 725 cubic yards of mine waste from the Stevens Gulch drainage bottom and placement in the Paymaster Repository following full amendment of the removal area with cement kiln dust. The excavation area was regraded and revegetated, and 200 feet of stream channel reconstructed. A grout seal was placed in the Capital Mine adit to eliminate seasonal discharge of water from the adit.

2.1.7 Consolation Mine

The Consolation Mine is a relatively small mine located in lower Shave Gulch (**Figure 2-1 and 2-1f**) on patented mining claims that were reclaimed by ASARCO in 1997 (Hydrometrics 1998b).

The Consolation Mine consisted of two collapsed adits (upper and lower) and associated mine waste piles. The mine waste occurred as a relatively thin pile covering about 2.5 acres of hillside below each adit. Reclamation involved consolidation of the mine waste into the lower adit area by pushing the upper mine waste downhill into the adit, and hauling the lower mine waste pile uphill to the adit. Approximately 2,200 cubic yards of mine waste was placed into the prepped adit area, regraded to match the surrounding topography, the upper 12 inches amended with cement kiln dust, covered with soil (12-inch minimum), and the entire removal area revegetated.

2.2 TEMPORARY WATER QUALITY STANDARDS IMPLEMENTATION PLAN

In 2004, ASARCO resumed reclamation activities in upper Mike Horse drainage under the Temporary Water Quality Standards Implementation Plan (IP; Hydrometrics 2000). Routine water quality monitoring subsequent to the 1998 in-place mine waste closure showed continued seepage of poor quality water from the base of two mine waste piles, referred to as piles 1 and 4, in upper Mike Horse drainage. In order to address the seepage of poor quality water, and potential metals loading to Mike Horse Creek, ASARCO initiated mine waste removal actions in 2004 at Waste Piles 1 and 4. Approximately 12,000 cubic yards of mine waste/soil were removed from Upper Mike Horse drainage and hauled to the Paymaster Repository for permanent disposal. An estimated 3,000 cy of additional mine waste/soil was removed in 2005. The 2004 Upper Mike Horse reclamation action is described in the DEQ and USFS-approved 2004 reclamation work plan (Hydrometrics 2004).

The Upper Mike Horse reclamation is the only temporary standards reclamation activity to be initiated since the IP was approved in 2000. Due to the lack of progress with the IP, the BER revoked the temporary water quality standards effective December 22, 2006, and is applying the Montana water quality standards at the UBMC.

2.3 FUTURE RECLAMATION PLANS

At the present time there are a few reclamation activities in various stages of planning for the UBMC by entities other than DEQ. These include:

- Final ASARCO EE/CA (Hydrometrics 2007) and the subsequent Action Memorandum released by the USFS (USFS 2007);
- Paymaster Repository Expansion Siting Investigation (USFS, Hydrometrics); and
- ILS/Wetland Treatment System rebuild by ASARCO in 2007 and 2008.
- Draining (initiated) and removal of Mike Horse Tailings Dam by ASARCO in 2007 and 2008.

These items are being researched and evaluated outside of the DEQ RI and Feasibility Study process, and therefore this RI will not focus on these reclamation/remediation components.

Figure 2-1 Overview of Mine Waste Sampling Locations
Figure 2-2a Overview of Mine Waste Areas – Edith Mine and No. 3 Tunnel
Figure 2-3b Overview of Mine Waste Areas – Paymaster Mine
Figure 2-4c Overview of Mine Waste Areas – Capital and Mike Horse Mines
Figure 2-5d Overview of Mine Waste Areas – Carbonate and Consolation Mines
Figure 2-6e Mary P and Anaconda Mines
Figure 2-7f

3.0 NATURE AND EXTENT OF CONTAMINATION

DEQ prepared a Comprehensive Data Summary Report (DSR) for the UBMC (DEQ 2007). This report 1) presented a compilation of all existing and available information relevant to the UBMC; 2) evaluated the data by comparing it to appropriate screening levels; and 3) identified additional data gaps. The primary data gaps identified in the DSR report that applied to the 2007 Fall expeditious sampling event included the following:

- Soil data, including background samples, to determine the nature and extent of the contamination and assist in the preparation of ecological and human health risk assessments.
- Macroinvertebrate data to determine aquatic health.
- Sediment data to characterize current conditions within the river channel bottom and assist in the preparation of ecological and human health risk assessments.
- Surface water data to determine the site-wide nature and extent of surface water contamination including areas downstream of BRSW-16 and to assist in the preparation of ecological and human health risk assessments.
- Surface water data to determine the nature and extent of surface water contamination within the localized tributaries including, but not limited to, Paymaster Creek and Stevens Creek and to assist in the preparation of ecological and human health risk assessments.
- Alluvial and bedrock groundwater data, including water quality and aquifer characterization data. This task included the installation of additional monitoring wells, to determine the nature and extent of groundwater contamination and will assist in the preparation of ecological and human health risk assessments and the evaluation of remedial actions.
- Mine site inventories of previously unidentified or unsampled waste rock piles, prospects pits, and underground mines located in Stevens Creek and other areas of the complex.

The fall 2007 SAP was developed to address the above data gaps. Other data gaps identified in the DSR included those related to vegetation and small mammal data. Vegetation was not sampled under the 2007 SAP because it was too late in the growing season to collect good vegetation data. Vegetation will likely be collected and evaluated during the 2008 investigation. Small mammals were not collected in 2007 because Tetra Tech believed that the data gathering activities during the 2007 fall sampling event would support the identification of potential areas of concern for small mammal sampling in 2008.

The objectives of the expeditious 2007 fall field event were to evaluate the site during low water conditions, begin establishing the lateral extent of contamination for surface water and soils, and the lateral and vertical extent of contaminants in groundwater at the Facility, and to support human health and ecological risk assessments. Results from this 2007 fall sampling event will help evaluate whether there are soil impacts that could affect vegetation and mammals. If the data indicates there are potential affects, mammal sampling will likely occur during the 2008 field investigation. Additional field work may be performed for soil, sediment, mine waste, surface water, and groundwater in 2008 if the data collected during 2007 indicates additional data is needed to support the RI.

The following sections provide a summary of historical information for each media type investigated, present a summary of the 2007 fall investigation protocols, and identify additional data gaps that became apparent as a result of the 2007 sampling. In general, although 2007 geochemical data is presented in tables at the end of Chapter 3, interpretation of 2007 sampling results will occur as part of the 2008 winter work. Data gaps identified thus far from the 2007 investigation and remaining from review of the DSR are also included in each of the sections that follow.

3.1 MINE WASTES

3.1.1 Historic Mine Waste Sampling

Mine wastes, including waste rock and tailings that has been transported and redeposited as sediments above the upper marsh, have been sampled during various characterization efforts beginning in the late 1980s. Soil samples have also been collected from beneath removed mine waste deposits, from areas where soils are intermixed with mine waste, and from non-impacted areas representing natural background conditions. **Figure 2-1** and **Figures 2-1a** through **2-1e** show the location of the mine waste areas.

A summary of historic mine waste sampling, by area within the UBMC, is provided in the DSR and the complete dataset for most samples are presented in appendices and tables of that report. Data for samples collected by Hydrometrics from 1991 through 2004 are reported in Appendix B of the UBMC EE/CA prepared by Hydrometrics (2007). Data for 210 soil samples are reported in laboratory reports in Appendix C of the DSR. These reports are an archive of historic data extending back to 1987; however, sample locations and descriptions are not provided in the archive. **Table B-1** in **Appendix B** summarizes the number of samples collected, their general location, analyses performed, whether sample location maps are available, and the original reference where these data were reported. These original documents will be reviewed as part of the winter 2008 work to determine the relevance of the sample sites and their results with respect to current levels of contamination at the UBMC Facility.

Most historic soil samples were analyzed for total whole-rock metal concentrations although a description of the methods used are not available for all samples. Similarly, acid-base accounting (ABA) was performed on a subset of the historic samples to assess the potential for acid generation but it is not clear whether the samples were analyzed using the now common modified Sobek procedure or if they were analyzed using another method.

Data exist for Toxicity Characteristic Leaching Procedure results for five samples, dissolved metal concentration data measured during leach testing of 12 samples, run-off samples collected from five waste areas, and metal concentrations measured in extracts [5 percent acetic acid] from 39 samples. While these data are useful for assessing potential loading to surface water it is not clear how they compare to more recently accepted methods for evaluating metal mobility such as the Synthetic Precipitate Leaching Procedure (SPLP) or the Meteoric Water Mobility Procedure.

3.1.2 Sites

Tetra Tech investigated several types of mine wastes and mine areas as part of the 2007 fall investigation. These include the following:

- Mine Inventory – including mine wastes, prospect pits and mines,
- Previously Reclaimed Areas – where mine wastes were either removed or reclaimed in place,
- Dispersed tailings along the Blackfoot River,
- Over-bank deposits along the Blackfoot River and Beartrap Creek, and
- Background sampling for soils and surface water.

The purpose of sampling these areas was to fill data gaps remaining following previous investigations and other remedial efforts at the UBMC. Background soil sampling was conducted to evaluate soil conditions in areas not impacted by mining activities. The following sections describe the activities completed in 2007. The 2007 SAP (Tetra Tech 2007) presents additional details regarding the activities performed in 2007.

2007 Mine Inventory

Beginning in 1993, mine waste piles associated with the Carbonate, Anaconda, Edith, Paymaster and Mike Horse mines were removed and placed in engineered repositories (**Figure 1-2**) or reclaimed in place to limit potential leaching and subsequent mobilization of metals to waters of the State. Section 2 provides details on the removal and reclamation efforts for each of these areas. In all, approximately 100,000 yd^3 of mine waste have been removed from these select mine sites and isolated in three on-site engineered repositories located near the Carbonate, Paymaster and Mike Horse mines (**Figure 1-2**). In addition to mine waste removal, ASARCO and ARCO constructed a passive water treatment system in 1996 to treat drainage from the Mike Horse Adit as well as the combined discharges from an adit and shaft at the Anaconda Mine.

Despite these reclamation efforts, mine waste still exists throughout the UBMC in several of the tributary areas of the upper Blackfoot River drainage. Tetra Tech completed a preliminary mine inventory during the fall 2007 to identify some of the remaining mine waste within portions of the UBMC. Many other areas remain to be investigated. Tetra Tech completed the 2007 inventory on mine sites in Stevens Gulch and nine other priority areas within the UBMC. **Table B-2 in Appendix B** presents a summary of mining related impacts documented during the 2007 field effort. A significant number of mining-related features such as mine waste areas, shafts, and adits were documented using a recreational-grade hand held GPS unit and photographs were taken of significant mining features in each area. The nine priority sites investigated in fall 2007 include the following:

- Carbonate No. 2 Claim – Tunnel No. 2 Adit located approximately 200 feet north of US Highway 200.
- Paymaster Claim (Patented) – No. 2 Tunnel located approximately 550 feet upstream of No. 1 Tunnel.
- Paymaster Claim (Patented) – An improperly abandoned drill hole (possibly a core hole) located approximately 200 feet upstream of Tunnel No. 1.
- Belle of the Hill Claim (Unpatented) – Tunnel located 50 feet from Blackfoot River.
- Copper Wreath Claim (Patented) – Tunnel No. 10 (potential dump site) located 75 feet northeast of Capital Mine and approximately 200 feet from Stevens Creek.
- Denver Claim (Patented) – Tunnel No. 9 (potential dump) located 75 feet west of Tunnel No. 10 and 125 feet from Stevens Creek.
- Capital Claim (Patented) – Tunnel No. 12 located 225 feet from the Denver claim, 350 feet from Capital No. 2, and 25 feet from Stevens Creek.
- Capital Claim (Patented) – Tunnel No. 11 located 75 feet southwest of Tunnel No. 12 on Stevens Creek and approximately 300 feet downstream of the Capital Mine.
- Capital Mine – located 50 feet from Snowdrift Mine and Stevens Creek.

The following sections summarize the data obtained during the 2007 inventory.

Stevens Gulch

Field investigations in the Stevens Gulch drainage resulted in 93 recorded sites relating to past mining activity. Of these, 35 of the sites are exploration drill pad locations. The drill pad footprint was similar throughout all sites resulting in a high cut bank and a pad area approximately 100 feet by 40 feet. Drill cutting piles and other residual exploratory material, possibly some from road or pad building, in these areas amounted to approximately 11 yd^3 and was located along the downhill edge of the drill pad at most sites. The downgradient path of waste water used during drilling and subsequent runoff from the waste piles is visible at most of the drill pads and appears to inhibit understory vegetation growth. Timber growing in the debris appears to be unaffected by the waste stream from the drill pad. Some debris flow from the drill pad extends as much as 500 feet downslope with widths of approximately 20 feet and a depth of approximately 0.5 feet.

Old cut timbers and other building materials were observed at a few of the drill pad sites. The timbers were likely used during drilling to level the rig or may indicate potential past mining activity other than drilling. No adits were identified at the drill pad sites. One drill pad had a 4-inch pipe extending from just below the cut slope and was producing low volumes of water, which infiltrated to the subsurface nearby. Two openings, probably washed out drill hole collars, at two drill areas, were located on pad sites, posing a potential risk to human and wildlife safety. One of the openings was approximately 12 inches in diameter at the surface and expanded to nearly 2 feet in diameter at a depth of 10 feet below ground surface. Total depth of the opening is unknown. The other opening was 6-inches in diameter; the total depth of the second opening is also unknown.

Two open mine adits were located in Stevens Gulch just below the Capitol Mine reclamation site. The first adit was collared in a rock outcrop. The rock outcrop runs adjacent to the stream channel for approximately 50 feet. The dimensions of the adit portal were approximately 3 feet by 4 feet and was observed to extend more than 30 feet into bedrock where it opens up into a 7-foot high chamber. No water was issuing from the portal, nor was any streambed staining observed at the adit mouth. Mine wastes were observed within the floodplain along almost the entire length of Stevens Creek from the first adit to where Stevens Creek intersects the Blackfoot River. Some staining was observed in Stevens Creek. The source of the staining to the creek bottom is likely from multiple sources; however, there is an estimated 28 yd^3 of waste rock located within 50 feet of the first adit which could be one source of staining.

The second adit is located approximately 400 feet northeast of the first adit and occurs nearly 200 feet upslope and away from Stevens Creek. The adit portal appeared to have been backfilled and only a small portion of the original adit opening was visible (1 foot x 2.5 feet opening). A timber was visible at the adit portal that supported the overhanging rock at the entrance. Two small waste rock piles containing approximately 29 yd^3 were crossed by an access road that separated the mine adit from the main waste rock pile that was estimated at about 1,000 yd^3 in size and was located 60 feet downslope of the adit portal. The main waste rock pile was located adjacent to an ephemeral stream channel and may contribute sediment to Stevens Creek during spring runoff.

Two locations in Stevens Creek were observed from which groundwater was flowing from past mining related disturbances. One discharge occurred on an exploratory drill pad, where a 4-inch pipe protruded from the toe of the cut slope at a 45-degree angle and produced a small amount of water. Alder growth in the vicinity of the pipe did not appear to be negatively affected by the water. The second discharge was located approximately 70 feet from Stevens Creek and produced enough water that a small pond has formed that was approximately 6 feet deep and occupied an area of about 750 ft^2. The area had a faint sulfur smell and gas bubbles were present at the spring source. Herbaceous vegetation surrounding the pond appeared to have good vigor; similarly, shrubs adjacent to the area appeared healthy.

Two large waste rock piles were located in the head of Stevens Gulch. The first area was identified as the Viking Mine. The adit to the mine was collapsed. The estimated mine waste footprint and volume for the waste rock pile is approximately 750,000 ft^2 and 20,000 yd^3 (540,000 ft^3), respectively. Stevens Creek was dry below the mine waste pile at the time of the 2007 investigation; however, white mineral staining was evident on streambed substrate within the stream channel. The waste rock pile encroached upon and locally blocked the stream channel and likely contributes mine waste to the channel during precipitation events. Iron staining was evident over a small area (10 feet x 15 feet) on the road near the collapsed adit. A second large waste rock pile was observed on the ridge separating Stevens Gulch from Mike Horse Creek. Mine waste at the second waste rock pile did not appear to be in contact with any surface water. The waste rock pile was associated with a large cut slope and was approximately 5,440 yd^3 (146,880 ft^3) in volume. Several old exploratory trenches were located slightly downslope of the second waste rock pile. The trench covered approximately 1,500 ft^2.

The upper reach of Stevens Creek has mine waste deposits along its narrow floodplain. High flow spring runoff events likely transported mine waste materials from the Viking Mine and other small mining operations and prospects adjacent to the creek downstream. The lower reach of Stevens Creek that extends downstream of the Paymaster road to the intersection with Mike Horse Creek Road, exhibited signs of past mine waste contamination. This is consistent with mine wastes and disturbance associated with the No. 3 Tunnel located west of the Stevens Creek channel.

Paymaster

The mine waste inventory found numerous small prospect pits and exploratory trenches on the ridgeline above the main adit entrances for the Paymaster Mine. One pit measured 16 feet in diameter and 15 feet deep. The associated waste rock pile was 106 yd^3. The largest disturbed area inventoried as part of the Paymaster was located approximately 500 feet south of the end of the access road that runs adjacent to the Paymaster adit reclamation areas (believed to be the Paymaster No. 1 Tunnel and Paymaster No. 2 Tunnel). The excavated trench at this location was 3,060 ft^2 in size and extended from the access road to the waste rock pile. The waste rock pile associated with this area was 1,288 yd^3. The toe of the waste rock pile was 5 feet from Paymaster Creek and likely contributes sediment to the creek during high flow and precipitation events.

Mining activity was infrequent upstream from the aforementioned trench to the historic cabin site. The only area of consequence was a 5 yd^3 trench with a similarly sized waste rock pile. Tailings material was not evident at site. A small side channel to Paymaster Creek was identified approximately 100 feet upstream of the cabins. It was unclear whether the channel (75 feet long) was associated with historic mining activity. Paymaster Creek is intermittent from approximately 50 feet below the cabin site to the head of the drainage. An exploratory drill pad was approximately 300 feet above the cabins. A wildlife wallow was located adjacent to the intermittent stream channel just upstream of the exploratory pad.

Two mine sites were located in the head of the Paymaster Creek drainage. The upper most area consisted of a trench measuring 18 yd^3 and a waste rock pile (167 yd^3). The larger of the two sites was located in the head of the intermittent portion of Paymaster Creek. The historic adit entrance no longer exists but an area of moss indicates were the entrance was likely located. An exploratory drill pad now occupies the site with a cut slope (1,950 ft^2) and a mine waste pile that extends from the edge of the pad 130 feet downslope. A small exploratory road crosses at the toe of the waste rock pile, effectively separating the waste rock pile from the origin of the intermittent channel of Paymaster Creek. The waste rock pile contains approximately 2,689 yd^3 of material.

Carbonate

A prospect pit and adit were observed north of Meadow Creek Road off of US Highway 200 in the Carbonate No. 3 area. A small 11 yd^3 waste rock pile was associated with a 9,375 ft^2 excavation pit and adit. Cement footings were located adjacent to the excavation pit. To the east of this site, a level bench was observed that contained several large cement footings and occupied and area of 5,213 ft^2. No mine waste was observed at in this area. Two small roads branched from Meadow Creek Road 100 feet from the junction with US Highway 200.

Belle of the Hill

The Belle of the Hill mine is located along the Blackfoot River across from the Mary P. mine and at the toe of the valley slope. No adit or mine workings are visible. Approximately 700 yd^3 of waste rock extends from the toe of the valley slope at the site. Changes in vegetation at the site indicated the presence of an intermittent spring. Vegetation vigor and diversity appeared good in this area. Several small (25 ft^2) prospect pits were observed upslope of the mine area.

Previously Reclaimed Areas

Tetra Tech sampled soil at several mine waste areas during this 2007 investigation in areas where mine waste was either removed or reclaimed in-place. The purpose was to evaluate the effectiveness of removal actions by evaluating whether metals remain along the perimeters and central areas of the remediated areas at concentrations that are a potential threat to human health and the environment, and evaluate whether potential metals may be mobilized from the area. In areas where mine waste was reclaimed in-place, sampling was performed to evaluate whether metals remain or are exposed in soils in the reclaimed areas at concentrations that are a potential threat to human health and the environment, and evaluate whether potential metals are being mobilized from the waste area.

Tetra Tech sampled the perimeter of each mine waste/mine waste removal area by taking one soil sample for every 50 linear feet surrounding the removal/reclamation area. The samples were collected from the approximate edge, just beyond the estimated removal/reclamation limits. The goal of sampling was to focus primarily on the margins of the reclamation. The samples were collected from each reclaimed area from the 0- to 6-inch depth interval, beginning at the base of the current root layer, if present. One to two surface soil composite samples (0 to 6-inch) were also taken from the central portions of each reclaimed mine waste area.

Each sample was analyzed by x-ray fluorescence (XRF) for arsenic, cadmium, copper, lead, manganese, mercury, and zinc. Select samples were also submitted to the analytical laboratory for total metals analysis, acid base accounting (ABA), and SPLP analysis.

The following provides a list of the areas that were sampled during the 2007 investigation. **Figure 2-1** and **Figures 2-1a** through **2-1e** show the location of each mine waste area. **Table B-3** in **Appendix B** presents the XRF screening results for the samples and presents the laboratory analytical results.

- Anaconda Mine Waste Removal Areas: Two mine waste removal areas are located on the south-facing hillside overlooking the Anaconda constructed wetlands on the north side of the upper Blackfoot River. Tetra Tech sampled soil from the two mine waste removal areas associated with the Anaconda Mine and collected grab samples from two apparently unreclaimed mine waste areas north of and topographically above the Anaconda Mine removal areas. A third area that had three additional waste piles was located north, topographically above, the western-most reclaimed area, initially mistaken for one of the two larger reclaimed areas, was also sampled in 2007. Field personnel sampled the perimeter and collected a composite from the center of one pile and collected a sample of mine waste from the other two areas. The DSR and other reports reviewed in preparation of this RIWP did not indicate other reclamation areas in the area above the Anaconda Mine. In addition, field personnel indicated that the additional waste piles likely had not been reclaimed. as there was no vegetative growth and the mine waste was bright colored and smelled of sulfur. Samples collected from these areas were analyzed with the XRF. Interpretation of the results is pending. Additional sampling of these areas may be needed during the 2008 investigation.
- Capital Mine Waste Removal Area: The area has two mine waste removal areas. Tetra Tech combined the two removal areas into one soil sampling area as the individual reclaimed areas were indistinguishable.
- Carbonate Mine Waste Removal Areas: Tetra Tech sampled soil from the perimeter and collected one composite soil sample from the mine waste removal area located along US. Highway 200 and adjacent to the Carbonate Mine access road. A second composite was not collected because of wetland conditions in approximately one-half of the removal area. This area formerly contained a combined waste rock pile and tailings pile. The DSR reported that this area contains between 13 to 17 inches of cover soil.
- Consolation Mine Waste Removal Areas: Two mine waste piles, one above the adit and one below the adit, were removed from this area and consolidated and placed in the Consolation Mine adit. Tetra Tech combined the two reclaimed removal areas into

one soil sampling area as the individual areas were indistinguishable. Field personnel also collected one sample east of (above) the removal areas that appeared to be possible mine waste.

- Edith Mine Waste Removal Areas: The Edith Mine area included 11 mine waste piles that were removed, regraded, and revegetated. Several of the mine waste areas were combined into investigation groups because some of the small individual removal areas were not visually distinguishable. Tetra Tech sampled the individual areas and investigation groups.
- No. 3 Tunnel: Mine waste was removed from No. 3 Tunnel in 1996. Tetra Tech sampled this area and collected additional grab samples from two mine waste features north of the Paymaster access road. The two features include a very small depression, possibly detention pond, and what are apparently fine-grained tailings.
- Mike Horse Mine Waste Piles and In-Place Reclamation Areas: Five mine waste rock piles located south of the Mike Horse Mine covering approximately three acres were reclaimed in-place by Asarco in 1998. Tetra Tech sampled soil at three reclaimed waste rock piles in 2007. The two remaining piles were removed in 2004/2005 and the removal areas were once again reclaimed during the fall of 2007.
- Paymaster Mine Waste Removal Areas: Three mine waste removal areas are associated with the Paymaster Mine. The northernmost waste removal area lies beneath a constructed wetland unit. This waste removal area was not sampled during the 2007 investigation. Tetra Tech sampled soil at the two reclaimed southern waste removal areas.

Dispersed Tailings

Soil samples were collected from six test pits excavated in dispersed tailing areas to evaluate concentrations of metals in these mine wastes along the upper Blackfoot River corridor (**Figure 3-1**). The test pits were located according to a 2005 work plan by Hydrometrics to further investigate these tailings. The test pits were excavated using a backhoe and extended through the total observable depth of mine tailings, until either the mechanical limits of the backhoe were reached, or to the groundwater-soil/mine waste interface. Tailings samples were collected from three depth intervals over the 0-2 inch, 2-12 inch, and 12-24 inch ranges. In addition, samples were also collected across a one foot interval above and below the upper native soil contact. Finally, if the native soil materials appeared impacted by leaching of metals from overlying tailings, field personnel collected additional samples over 12-inch depth intervals deeper in the test pit until soil appeared to be unimpacted by tailings. The soil samples were screened with an XRF detector to evaluate metal concentrations and to make a determination of which of the samples would be analyzed for ABA and SPLP (one sample per test pit) by the analytical laboratory. In addition, the one sample selected for analysis was also analyzed for total metals content by the laboratory for arsenic, cadmium, copper, lead, manganese, mercury, and zinc; and for pH, electrical conductivity, and total organic carbon. **Table B-4** in **Appendix B** presents the analytical results for the dispersed tailings samples.

Over Bank Deposits of Mine Waste

In 1975, the Mike Horse Tailing Impoundment located on Beartrap Creek breached during a heavy rain event. The breach resulted in the release of tailings waste materials into the active channels of Beartrap Creek and Blackfoot River, their associated floodplains, and at least the Upper Marsh along the Blackfoot River. Obvious thick and laterally continuous sedimentary deposits from the release are present along Beartrap Creek and Blackfoot River and less obvious indications are present in the Upper Marsh and downgradient reaches of the Blackfoot River as indicated by historic metal concentrations in sediment and surface water. The cross-section of Beartrap Creek canyon is very narrow and appears to have forced the waters associated with the breach high onto the sidewalls of the canyon. This is evident from the debris line created by the turbulent flow which resulted in downed trees and other debris that became entangled in the rooted tree-line when the waters receded.

Tetra Tech has termed the tailings and other eroded mine waste released and/or re-mobilized as a result of the impoundment breach as “over bank deposits.” Historic soil data has been collected by other investigators for the flood plain areas directly adjacent to the streams and from specific depositional features containing apparent mine wastes present along the Blackfoot River. However, the lateral extent of mine waste deposition at the edges of the floodplains from the breach and other potential flood/high water events was not delineated during previous investigations. Therefore, Tetra Tech’s field efforts in 2007 focused on evaluating the lateral extent of the impacts from this breach and other high water/flood events by evaluating the distal edges of tailings/impacts. The following summarizes the method used, which was changed in the field, following finalization of the 2007 SAP (Tetra Tech 2007), to provide more comprehensive data for planning and remediation purposes.

- Field personnel set a temporary control point at the beginning of both the Blackfoot River and Beartrap Creek for use as a reference point for all subsequent downstream measurements. Measurements for Beartrap Creek commenced at the confluence of Mike Horse Creek with Beartrap Creek and at the confluence of Anaconda Creek and Beartrap Creek which is the beginning of the Blackfoot River.
- Field personnel established sampling transects at 100-foot intervals downstream from the respective control point (roughly following the stream channel). The transects extended on either side of the stream (roughly east to west across the Beartrap Creek floodplain and approximately north to south across the upper Blackfoot River to the edge of visible tailings impacts. A control stake was set at the estimated edge of tailings (EOT) for each respective stream segment to establish a relative reference point for sample locations.
- Sample locations along each transect were measured relative to the EOT stake (e.g., Samples collected from points closer to the stream than the EOT stake, were assigned a negative number while samples collected further away from the stream than the EOT stake were assigned a positive value. Intervals along sampling transects generally

consisted of -12.5 feet, 0.0 feet (at EOT) and +25.0 feet from the EOT stake. The stake locations were placed at these intervals in the attempt to verify the edge of the over bank tailings deposits. Soil samples at each location were collected from the 0- to 6-inch depth interval. Some sample locations in Beartrap Creek are high above the level of the creek due to evidence of depositional debris and possible tailings higher up on the hillside as a result of the initial pulse of water and debris from the breach.

- The EOT stakes along the Blackfoot River and Bear Trap Creek were surveyed using a Trimble GPX handheld global positioning satellite (GPS) device with sub-meter accuracy.

Figure 3-2 through **Figure 3-4** present the EOT stake locations. The samples were screened on site with an XRF detector with one in every 10 samples being submitted to the analytical laboratory for analysis of pH, electrical conductivity, total organic carbon, and total metals (arsenic, cadmium, copper, manganese, lead, mercury, and zinc). One-half of the samples submitted to the laboratory were also analyzed for ABA and SPLP. **Tables B-5 and B-6** in **Appendix B** present the XRF and analytical results for the samples for Beartrap Creek and Blackfoot River, respectively.

General observations made during the 2007 field investigation indicated that tailings deposition along Beartrap Creek and the upper Blackfoot River above the Upper Marsh appeared to extend almost the entire width of the floodplain; essentially extending from valley wall to valley wall within the narrow canyon of Beartrap Creek and from at least Mike Horse Creek Road to the hillside along the upper Blackfoot River above the Upper Marsh.

Background Soil

Tetra Tech collected 11 background soil samples from the UBMC Facility. Two background soil samples were collected previously, one in the Beartrap Creek drainage and one in the Stevens Gulch drainage during a previous investigation.

Field personnel collected six soil samples from highly mineralized areas and five from lesser- to non-mineralized areas. The samples were collected from areas away from known or suspected areas where mining activities took place. The purpose of collecting the background samples was to evaluate background baseline values of metals in several drainages for comparison with metals concentrations in impacted areas of the facility and in support of evaluations made during the human health and ecological risk assessments.

Field personnel collected the samples by hand excavating with a shovel or hand auger. Field personnel collected the soil samples from the 0- to 6-inch depth interval. Forest duff was cleared from the sample location prior to excavation and sampling. If vegetation was present, the sample was collected from an interval at the base of the root mass.

Field personnel recorded the coordinates of each sample location using a recreational grade hand-held GPS unit. **Figures 1-2** and **2-1** show the location of each background soil sampling point. The following summarizes the areas that were sampled:

Non-Mineralized Soils

- Anaconda Creek drainage soil sampling area: Surface water samples from this drainage meet Montana water quality standards, and there are no known mining activities associated with this drainage with the exception of the Anaconda Mine at the confluence of Anaconda Creek and Blackfoot River. Two background soil samples (ACBG-1 and ACBG-2) were collected from this area.
- Beartrap Creek drainage soil sampling area: Surface water of Beartrap Creek was sampled most recently in October 2007 as part of preparation efforts for removal of the Mike Horse Tailings Impoundment. This sampling indicated that surface water in Beartrap Creek above the impoundment meets Montana water quality standards (DEQ 2006). One additional background soil sample (BCBG-1) was collected from the Beartrap drainage during this investigation.
- Meadow Gulch soil sampling area: Meadow Gulch meets Montana water quality standards and has had few, if any, mining impacts. Two soil samples (MGBG-1 and MGBG-2) were collected from the drainage to evaluate soil geochemical conditions in this drainage.

Highly Mineralized Areas

- Paymaster Creek Drainage: Surface water and soil in this drainage is impacted from mining activities. One background soil sample (PCBG-1) was collected from this drainage to provide information on metals concentrations in soil away from known mining-impacted areas.
- Stevens Gulch Drainage: Mining has occurred in this drainage. A background sample was collected in Stevens Gulch during a previous investigation. DEQ has the data for this sample. One additional background soil sample (SGBG-1) was collected from this drainage to evaluate background soil conditions.
- Swamp Gulch Drainage: Mining has occurred in this drainage. Two soil samples (SWBG-1 and SW-BG-2) were collected from this drainage to provide information on metals concentrations in soil away from known mining-impacted areas.
- Shave Gulch: Mining has occurred in this drainage although the geologic map appears to show less mineralization than other areas, such as the Paymaster and Stevens Gulch drainages. Two soil samples (SHBG-1 and SHBG-2) were collected from this drainage.

Background soil samples were analyzed by XRF. In addition, the three background soil samples with the highest metals concentrations, as measured with the XRF, were also submitted for metals analysis for and ABA and SPLP to evaluate natural conditions related to acid generation and metal mobility from the soil. The XRF and laboratory analytical results are presented in **Table B-7** in **Appendix B**.

Acid Base Accounting (ABA)

ABA data from soil and waste samples are used to assess the potential for acid generation. Acid-base account testing determines the Acidification Potential (AP) and Neutralization Potential (NP) of a sample (Sobek et al. 1978). The test uses relatively complete digestion of finely ground rock, and therefore conservatively estimates the reactivity of available sulfide. AP and NP are reported in units of tons $CaCO_3$ / kiloton (1000 tons) of rock. The ratio of these values, along with Net Neutralization Potential (NNP = NP-AP. Also known as Acid Base Potential, ABP), are used by regulatory agencies to assess the acid generation potential of rock samples as shown in **Table 3-1**. Samples falling in the "uncertain" category require kinetic testing using humidity cells to evaluate whether they would generate acidic leachate over an extended period of weathering.

Acid-base account data for historic samples and those collected during the fall 2007 field effort will be summarized (**Table 3-2**). In addition to organizing those data according to the area, drainage, or specific site where samples were collected, they will also be discussed with reference to sample type as described in the 2007 SAP (i.e. mine waste, dispersed tailings, edge of waste removal area, etc). The data will also be compared to guidelines to rank the magnitude of potential impacts from individual waste deposits and to evaluate the success of removal and reclamation in areas of previous waste removal.

Table 3-1
Acid-Base Account Criteria for Classifying Acid Generation Potential of Rock Samples

Classification	Criteria for Classification[1]
Potentially Acid Generating	NP:AP[2] < 1 and NNP < -20 tons/kton
Uncertain Acid Generation Potential	NP:AP between 1 and 3 and/or NNP between -20 and +20 tons/kton
Unlikely to Generate Acid	NP:AP > 3 and NNP > +20 tons/kton

[1] From BLM (1996) and EPA (1994).
[2] NP = Neutralization Potential, AP = Acidification Potential, NNP = Net Neutralization Potential.

Table 3-2
Summary of Acid-Base Account Data for Waste and Soil Samples

	Criteria	Number of Samples	Minimum	Mean	Maximum
Carbonate Mine Reclamation Area	NP:AP[1]	1	N/A	30	N/A
	NNP[2]	1	N/A	7	N/A
Consolation	NP:AP	1	N/A	0.1	N/A

Table 3-2
Summary of Acid-Base Account Data for Waste and Soil Samples

	Criteria	Number of Samples	Minimum	Mean	Maximum
Mine Reclamation Area	NNP	1	N/A	- 8	N/A
No. 3 Tunnel Reclamation Area	NP:AP	2	0	1.3	2.7
	NNP	2	0	1.5	3
Paymaster Dump 1 (northern dump)	NP:AP	1	N/A	0.8	N/A
	NNP	1	N/A	0	N/A
Upper Anaconda Waste Pile Reclamation Area (southern area)	NP:AP	2	- 13	- 0.2	0.1
	NNP	2	- 17	- 13	- 9
Upper Anaconda Waste Pile Reclamation Area (northern area)	NP:AP	1	N/A	1.2	N/A
	NNP	1	N/A	1	N/A
Upper Anaconda Waste Pile (southern pile)	NP:AP	1	N/A	- 0.03	N/A
	NNP	1	N/A	- 220	N/A

[1] NP:AP is the ratio of neutralization potential to acid generation potential.
[2] NNP is net neutralization potential in units of tons $CaCO_3$ / kiloton of rock.

Metals Mobility

Precipitation can transport metals from waste areas to water resources in two ways. One way includes water contacting waste which can leach a portion of the total metal content from the waste and subsequently deliver that dissolved portion to surface or groundwater without transporting the parent waste material. Secondly, water or wind erosion can transport the waste material itself to surface water resources where the waste can be further transported as suspended sediment.

Data to assess soluble (i.e. leachable) metal mobility from samples are extremely limited in the historic dataset and were gathered using methods that are not heavily relied upon today. The historic data will be integrated with SPLP metal mobility data generated during the 2007 sampling program when they become available. Metal concentrations measured in SPLP test extracts, and from various historic tests, will be compared to Montana water quality standards to determine the likelihood that seepage or run-off from waste areas will negatively impact water resources (**Table 3-3**). Total metal concentrations will be used to identify and evaluate which waste areas have the greatest potential to impact surface water through erosion and sediment loading (**Table 3-4**). These data will be used to rank the magnitude of impacts from individual waste areas.

Table 3-3
Summary of Synthetic Precipitate Leaching Procedure Data for Waste and Soil Samples

	Arsenic	Cadmium	Copper	Lead	Manganese	Mercury	Zinc
	Milligrams per Liter						
DEQ-7 Standard[1]	0.01	0.005	1.3	0.015	0.05	0.00005	2.0
Carbonate Mine Reclamation Area	< 0.1	< 0.01	0.3	0.2	1.6	< 0.0001	< 0.5
Consolation Mine Reclamation Area	< 0.1	< 0.01	< 0.1	0.4	< 0.1	< 0.0001	< 0.5
No. 3 Tunnel Reclamation Area[2]	< 0.1	< 0.01	0.1	0.1	0.3	< 0.0001	< 0.5
Paymaster Dump 1 (northern dump)	< 0.1	< 0.01	< 0.1	0.4	< 0.1	0.00013	< 0.5
Upper Anaconda Waste Pile Reclamation Area (southern area)[2]	< 0.1	< 0.01	0.3	0.9	0.1	< 0.0001	< 0.5
Upper Anaconda Waste Pile Reclamation Area (northern area)	< 0.1	< 0.01	0.2	1.3	0.8	< 0.0001	0.6
Upper Anaconda Waste Pile (southern pile)	< 0.1	0.02	0.3	6.2	1.4	0.00032	3.3

[1] DEQ-7 human health standard for surface water.
[2] Values shown are means for two samples using half the reporting limit value for calculations involving analytical data that were below the reporting limit.

Fugitive Dust

Metals concentrations for each waste area (**Example Table 3-4**) will be compared to soil ingestion/dust inhalation guidelines (Tetra Tech 1996) and screening values to be developed in the human health risk assessment contained in this report in order to evaluate the potential hazard to recreational visitors and workers.

Data Gaps Identified

The following sections present preliminary data gaps. Additional data gaps may be identified following further review of project documents and receipt and evaluation of XRF and analytical laboratory results.

Historic Waste

The historic data show that mine wastes are typically acid generating and have elevated metal concentrations. However, very little historic data exists for the UBMC Facility to evaluate the extent to which soluble metals are released from wastes and impact water. The SPLP data collected during the fall 2007 sampling program will provide the type of data needed to assess potential metal mobility; however, samples were submitted for that analysis in a systematic fashion (i.e. every tenth sample) that may result in a great amount of metal mobility data for some areas while providing little for other areas. When the data are available it will be necessary to confirm that the sampling strategy provided adequate spatial representation of the site and various waste areas within it. If it is determined that additional SPLP analysis is required for a particular waste area, archived samples would be submitted for laboratory analysis.

Table 3-4
Summary of Average Metal Data for Waste and Soil Samples

	Arsenic	Cadmium	Copper	Lead	Manganese	Mercury	Zinc
	Milligrams per Kilogram						
Carbonate Mine Reclamation Area (n = 3)	26.8	7.4	402	385	1135	< 0.5	348
Central Edith Area Waste Pile (n = 3)	41.5	2.26	157	567	335	< 0.5	413
East Edith Area Waste Pile (n = 2)	12.0	0.35	60.0	98.2	506	< 0.5	68.8
West Edith Area Waste Pile (n = 2)	23.3	0.363	112	244	360	< 0.5	113

Table 3-4
Summary of Average Metal Data for Waste and Soil Samples

	Arsenic	Cadmium	Copper	Lead	Manganese	Mercury	Zinc
	Milligrams per Kilogram						
Capital Mine Waste Pile (n = 1)	150	0.97	130	476	741	< 0.5	343
Consolation Mine Reclamation Area (n = 3)	371.6	3.0	252	2,590	642	< 0.5	481
No. 3 Tunnel Reclamation Area (n = 3)	29.4	0.65	411	150	1416	< 0.5	152
Paymaster Dump 1 (northern dump) (n = 1)	10.1	0.446	388	290	359	< 0.5	115
Paymaster Dump 2 (southern dump) (n = 1)	20.6	0.494	395	330	264	< 0.5	109
Upper Anaconda Waste Pile Reclamation Area (southern area) (n = 2)	78.6	0.99	646	5,070	482	< 0.5	337
Upper Anaconda Waste Pile Reclamation Area (northern area) (n = 2)	40	2.05	255	1140	1430	< 0.5	588
Upper Anaconda Waste Pile (southern pile) (n = 1)	121	1.4	954	22,600	117	< 0.5	641

n –number of samples

Another data gap exists with regard to the understanding of the historic sample population. While drainages that samples were collected from are often identified, the exact location within a given drainage is not made clear from the available data. For instance, while a sample may have been collected from the Anaconda Mine area it is not clear which of multiple discreet waste dumps may have been sampled. It is likely that exact sample locations are identified in reports where the data were originally described; however, these have not been reviewed for this draft. In order to make use of the historic data it will be necessary to determine the exact sampling location of each historic sample. It will also be necessary to determine whether reclamation activities have occurred in the sampled areas since the time the sample was originally collected.

Lastly, the approximate volume and area of each individual waste deposit must be determined. These data exist for some sites in the UBMC and volumes for dispersed tailings can be generated from data collected during the 2007 sampling event. If data for removed waste areas indicate the potential need to excavate contaminated soil, it may be necessary to determine the depth of impacts in order to calculate the total volume of impacted soil.

Mine Inventory

The information obtained for the sites identified and investigated during the 2007 mine inventory program indicated that there are several previously undocumented or unsampled mine waste piles, seeps or other water sources, and mine waste deposits in contact with surface water that require further investigation. For these areas, Tetra Tech recommends mine waste sampling, sampling of seeps and other sources of water observed, and surface water sampling to evaluate potential impacts from mine waste.

In addition to the sites that were investigated as part of the 2007 mine inventory task, field personnel also identified three mine waste piles that are present above the two mine waste areas that were formerly reclaimed on the slope above the Anaconda Mine. The perimeter was sampled and one composite sample was collected from one of these areas and one grab sample each from the other two areas were collected during the fall 2007 investigation. Additional sampling in 2008 for two or three of these areas will likely be required, pending results of the 2007 samples.

Other areas of the UBMC should be inventoried for mine wastes, especially those in close proximity to surface water and other mine related discharges to surface or groundwater. The Calliope Mine, located in Shave Gulch, should be inventoried in 2008 to evaluate potential impacts to Shave Gulch.

Figure 3-5 shows the approximate locations of proposed sampling locations associated with the inventoried mine sites in 2007.

Previously Reclaimed Areas

Preliminary data gaps identified for mine waste removal areas include further investigation of mine wastes on the hillside above the Anaconda Mine and No. 3 Tunnel mine waste areas, investigation of the former surface and subsurface at the location of the former Anaconda Mine waste pile areas that are currently beneath the Anaconda constructed wetland cells, and investigation of the former surface and subsurface at the location of the former Paymaster Mine waste pile that is currently beneath the former Paymaster constructed wetland. Other reclaimed waste rock removal areas and areas of waste rock reclaimed in place may require additional sampling pending results and interpretation of 2007 sample analysis. This sampling may include evaluating revegetation success and analyzing soil for nutrient chemical data (i.e. nitrate, potassium, phosphate, and organic carbon).

Dispersed Tailings Areas

At this time, there are no known data gaps; however, additional data gaps may be identified after receipt and evaluation of the XRF and analytical data for the dispersed tailing samples.

Over Bank Deposits

Additional data gaps will likely be identified following review and receipt of XRF and laboratory analytical data. Additional sampling to further define the lateral extent and margins of tailing deposits along Beartrap Creek and the Blackfoot River is expected.

Background Soil

Eleven new background soil samples were collected in 2007. Any need for collection and analysis of additional background soil samples will be determined following a review of the 2007 XRF and laboratory analytical results.

3.2 SURFACE WATER

3.2.1 Background Water Quality

Surface water quality data from sites upstream from historical mining activities are considered to represent background conditions. These data are available from historical investigations summarized in the DSR and from sampling conducted in fall 2007 by Tetra Tech. Sampling locations representing background conditions are present on Beartrap Creek upstream of the Mike Horse Tailings Impoundment (surface water site BRSW-1), upper Mike Horse Creek (BRSW-19), Anaconda Creek (BRSW-6), Shave Gulch (BRSW-10), Pass Creek (BRSW-11), Paymaster Gulch (BRSW-21, and PCSW-1 through PCSW-5),), and Swamp Gulch (BRSW-14). In general, background concentrations of dissolved and total recoverable metals in samples from streams other than Paymaster Creek were near or below detection limits. Zinc was the most commonly detected metal, followed by iron, manganese, copper, and aluminum. Sulfate concentrations were below 10 milligrams per liter (mg/L), and pH was 7.0 or above. Individual streams exhibited slightly different metals signatures.

Paymaster Creek showed higher sulfate concentrations, lower pH, and more frequent detections of metals and at higher concentrations compared to the other streams. It may be more appropriate to consider the sampled water quality background sites for Paymaster Creek listed above to be waters impacted by naturally occurring acid rock drainage (Furness 1998) , and if so we may need to look even further upstream for background water quality that has not been impacted by mineralization. Additional water quality sampling may also be warranted in the upstream reaches of Shave and Swamp Gulch.

Historic surface water samples from Beartrap Creek, Mike Horse Creek, and Anaconda Creek only occasionally exhibited dissolved metal concentrations, other than zinc, or total recoverable metals, other than iron and zinc, above detection limits with zinc and/or iron being detected more frequently. Detected metals were typically near the detection limit and included cadmium, copper, iron, manganese, and zinc. Zinc was the most commonly detected metal with dissolved concentrations detected in just over one-third of the samples and detectable total recoverable concentrations in nearly half of the samples.

Surface water in Shave Gulch typically had detectable concentrations of dissolved copper and zinc and total recoverable copper, iron, and zinc. Occasional detections of total recoverable aluminum, chromium, cadmium, and manganese also occurred. Concentrations of the metals listed were typically near detection limits.

Surface water from Pass Creek typically exhibited detectable concentrations of dissolved and total recoverable iron, manganese, and zinc with occasional detections of dissolved and total recoverable copper. Swamp Gulch samples were similar to those from Pass Creek, but with fewer detections of those metals.

Samples from Paymaster Creek differed from the infrequent, low-concentration detections of dissolved metals measured in samples from other locations. Paymaster Creek samples typically had slightly higher than detectable concentrations of dissolved aluminum, copper, iron, manganese and zinc, higher concentrations of sulfate, and pH below 7.0. Dissolved metals concentrations appear to increase and pH appears to decrease downstream, with notable changes at PCSW-1 and BRSW-21, located downstream of where the Mike Horse Fault System crosses Paymaster Creek. Furness (1998) postulated that the fault system contributes groundwater with lower pH and higher metals concentrations to the surface flow in Paymaster Creek. In addition, the 2007 mine waste inventory identified historical working and mine wastes upstream of this area.

3.2.2 Historic Sampling Sites

Surface water monitoring has been conducted within and downstream of the UBMC since the 1960s. Monitoring has been performed by various entities as part of water quality characterization within the Blackfoot watershed and downstream in support of reclamation activities. Data collected since 1994 are generally most representative of site conditions. Surface water quantity (discharge / flow) and water quality vary spatially and seasonally throughout the UBMC. A brief review by drainage area is provided below. .

Lower Mike Horse Creek

Lower Mike Horse Creek appears to be a gaining reach of stream with flows ranging from approximately 0.005 to 14 cubic feet per second (cfs). Surface water sampling on lower Mike

Horse Creek has been conducted seasonally since 1993. Samples collected since 2000 indicate elevated metal concentrations (except arsenic) increasing downstream. In general, metal concentrations and metal loading in lower Mike Horse Creek reach seasonal peaks during early spring “first flush” runoff in April or early May; possibly due to winter accumulation of metal-salts on rock, soil surfaces, and in near-surface sediments, and their subsequent dissolution in surface water during the early spring runoff.

Mike Horse Impoundment Area

Surface water flow from upper Beartrap Creek into the Mike Horse Tailings Impoundment generally ranges from approximately 0.1 to 7 cfs. Surface water quality upstream of the impoundment is generally of good quality, in comparison to Montana water quality standards, with no detectable total arsenic, cadmium, copper, lead, or manganese and low concentrations of iron and zinc. Seepage at the base of the Mike Horse Tailings Dam and immediately downstream generally contains higher metal concentrations than waters either within or upstream of the tailings impoundment, with samples presenting the highest concentrations recorded during spring runoff. The seasonal seepage at the dam toe was sampled five times from 2001 through 2004. The seepage can be generally characterized by appearance: those seeps exhibiting staining (white, yellow, or orange) have higher metals concentrations, while metal concentrations are lower in seepage areas without staining (clear seeps). In addition, clear seepage accounts for the majority (greater than 80 percent) of the total seepage from the dam toe. The variable chemistry of the seepage at the dam toe appears indicative of different sources. Clear seepage emerges near the seasonally flowing well TDMW-1, which exhibits water quality similar to the clear seeps. This suggests that the clear seepage derives from relatively clean alluvial groundwater likely flowing in buried alluvial channels beneath the tailings impoundment. The discolored seeps presumably derive from seepage through the dam which reacts with tailings to yield poorer-quality water (Hydrometrics 2007).

Beartrap Creek

Beartrap Creek from below the confluence with Mike Horse Creek to above the confluence with Anaconda Creek appears to contain both losing and gaining reaches with flows ranging from approximately 0.2 to 17 cfs. Surface water quality in Beartrap Creek has been monitored seasonally since 1993. Samples collected during 2000 through 2004 indicate neutral pH with metal concentrations similar at the upstream and downstream ends of Beartrap Creek. Cadmium, copper, lead, manganese, and zinc concentrations are all elevated with higher concentrations exhibited during spring runoff. A portion of the metals loading to this reach of Beartrap Creek appears to derive from upstream sources particularly during spring runoff events. However interaction of surface water with areas of dispersed or concentrated mine waste/tailings and or mixing with shallow groundwater affected by such deposits also appears to contribute to the metals loading of this reach (Hydrometrics 2007). Metal loading varies seasonally, with the highest loading rates during spring runoff and loading declining during the remainder of the year.

Anaconda Creek

Surface water discharge and quality in Anaconda Creek was monitored during the period of 1991 through 1996 at the mouth of the drainage. Flows range from approximately 0.05 to 17 cfs with highest flows generally during the month of May. Results of water quality analysis indicate surface water in Anaconda Creek is of good quality, in comparison with Montana water quality standards, with concentrations either below or near detection limits for total arsenic, cadmium, copper, iron, lead, manganese, and zinc. Neutral to slightly basic pH and low sulfate concentrations further indicate that water in Anaconda Creek is of good quality.

Upper Blackfoot River

The upper Blackfoot River within the UBMC extends from the confluence of Beartrap and Anaconda Creeks to an upper marsh system near the confluence with Pass Creek. The upper Blackfoot River is a gaining stream over this reach with flows ranging from approximately 0.7 to 90 cfs. Surface water quality over this reach has been monitored seasonally since 1991. Samples collected from 2000 through 2004 indicate the upstream and downstream concentration ranges are similar and exhibit moderately elevated metals concentrations (except arsenic). Metals concentrations and loads generally peak during spring runoff probably generated from upstream sources. However, fine grained tailings near the mouth of Shave Creek may contribute to metals loading during both high flow and low flow conditions. Additional loading to the Blackfoot River, just below its headwaters, occurs at the outfall of the Anaconda constructed wetland treatment system. The outflow is treated water from the combined flow from the Mike Horse Mine and Anaconda adits. Data indicate that metal loads increase from upstream to downstream throughout the year.

Stevens Gulch

Surface water discharge and quality in Stevens Gulch has been monitored since 1995. Data indicate surface water in Stevens Gulch typically exhibits low pH and relatively low concentrations of aluminum, copper, iron, lead, manganese, and zinc. Surface water loading of iron and lead generally occur in the upper portion of the drainage while loading of other metals and sulfate increases in the lower portion of the drainage. Comparison of 2001 data (after reclamation of the Capital Mine) to historic data generally indicated reduced concentrations in the upper portion of the drainage with no change at downstream monitoring locations. Previous investigations of the Stevens Gulch drainage have suggested that, in addition to being impacted by historic mining activities, metals concentrations may be naturally elevated in the central and lower portion of the drainage.

Paymaster Creek

Paymaster Creek enters the upper marsh system of the Blackfoot River opposite Pass Creek (**Figure 1-2**). Surface water monitoring in Paymaster Creek has been conducted since 1995. Field observations made during the historic mine inventory of Paymaster Creek drainage indicated that the Paymaster Creek channel just upstream of the upper road crossing, approximately 500 feet above the historic cabins is intermittent. Iron staining of streambed materials was not present through the intermittent portion of the channel at the time of the 2007 field investigation. The perennial portion of Paymaster Creek begins approximately 50 feet below the cabin site and was also devoid of iron staining. However, standing water appeared milky within the first 20 feet downstream of the perennial origin with iron staining on streambed material gradually increasing downstream from this point. Approximately 1,000 feet below the perennial origin, a small channel merges from the west side of the drainage the source of the surface water in this side channel is unknown but may be from a spring. The lowest reach of Paymaster Creek looses flow as it approaches and enters the upper Blackfoot River valley. During high flow, surface water of Paymaster Creek likely enters the Blackfoot River as dispersed flow through the upper marsh complex. However, at the time of the fall 2007 investigation, flow in the creek infiltrated to the subsurface approximately 100 feet prior to entering the Upper Marsh. Historic data indicates flow near the mouth of Paymaster Creek before entering the marsh system ranges from dry to approximately 5 cfs.

Water quality data confirm that surface water in the drainage contains elevated concentrations of aluminum, copper, iron, and manganese, with pH commonly less than 4.0 at various locations along central and lower Paymaster Creek. Monitoring stations in upper Paymaster Creek generally exhibit a higher pH of approximately 6 and lower metals concentrations. Elevated concentrations of metals are present both upstream and downstream of historic mining activities. Investigations of the Paymaster drainage have suggested that, in addition to being impacted by historic mining activities, metals concentrations may be naturally elevated in the central and lower portions of the drainage (Furniss 1998).

Shave Creek

Surface water discharge and quality in Shave Creek were monitored during the period of 1991 through 2001 at the mouth of the drainage. Flows range from approximately 0.04 to 17 cfs with highest flows generally occurring during the period of April through June. Results of water quality samples indicate surface water of Shave Creek is of good quality with concentrations below detection limits for arsenic, cadmium, iron, lead, and manganese and with low concentrations of copper and zinc. Good water quality is further indicated by neutral to slightly basic pH and low sulfate concentrations.

Pass Creek

Surface water discharge and quality data for Pass Creek are limited to the period of 1991 through 1993 at the mouth of the drainage as it enters the upper marsh system of the Blackfoot River. Flows range from approximately 0.02 to 1 cfs with highest flows generally during the month of May. Results of water quality samples indicate surface water of Pass Creek is of good quality with concentrations either below or near detection limits for arsenic, cadmium, copper, iron, lead, manganese, and zinc. Good water quality is further indicated by neutral to slightly basic pH and low sulfate concentrations.

Swamp Gulch

Monitoring of surface water discharge and quality in Swamp Gulch is limited to the period of 1991 through 1998. Monitoring has been completed upstream of historic mining activities and at the mouth of the drainage as it enters the upper marsh system of the Blackfoot River. Flows range from approximately 0.01 to 0.4 cfs with highest flows generally during the month of May. Swamp Gulch has not exhibited any consistent gaining or losing trends over the lower reach. Results of water quality samples indicate surface water of Swamp Gulch is of good quality above mining impacts, with concentrations either below or near detection limits for arsenic, cadmium, copper, iron, lead, manganese, and zinc. Good water quality is further supported by neutral to slightly basic pH and low sulfate concentrations. However, metal concentrations increase and pH decreases downstream of mining activities.

3.2.3 Spatial and Temporal Surface Water Trends

During 2001, ASARCO completed a surface water sampling program that focused on spatial and temporal trends through the UBMC. Sampling was conducted at up to 28 locations in Mike Horse and Beartrap Creeks, and main-stem Blackfoot River (to below the Meadow Creek bridge crossing). The program consisted of measuring flow and collecting surface water samples during the months of April, May, June, and October for total metals analysis in order to calculate metals loading. The following is a brief discussion of the investigation results.

April 2001

During the April 2001 monitoring event, concentrations of metals (with the exception of iron) and sulfate reached their maximum values in the Mike Horse Creek drainage, with decreasing concentrations downstream. Aluminum and copper concentrations were highest in the upper Mike Horse Creek drainage and then decreased rapidly.

Contrasting trends in loading downstream of the confluence of Mike Horse Creek and Beartrap Creek were exhibited by iron and sulfate, which generally showed increasing trends, as compared to the remaining metals, which were relatively stable. The maximum in-stream iron concentration was observed at sites downstream of a high iron concentration seep in lower Beartrap Creek drainage. In addition, a significant increase in iron load was noted in the Blackfoot River through the natural upper marsh. Some parameters show several loading “spikes,” suggesting multiple sources in the drainage, separated by reaches of metals removal, presumably through adsorption or precipitation. In general, the concentration and loading trends for April indicate primary loading sources in Mike Horse Creek, with downstream sources less significant.

May 2001

During the May 2001 monitoring event, concentrations of metals and sulfate tended to increase through upper Mike Horse Creek, decrease after the confluence with Beartrap Creek, then increase again fairly steadily through lower Beartrap Creek. Iron concentrations again reached a peak in Beartrap Creek downstream of an iron-rich seep. Lead showed numerous spikes in concentration, which could reflect erosion of particle-bound lead during elevated May flows in high-gradient reaches of the drainage.

During May 2001, loads of zinc, cadmium, iron, sulfate, and lead increased relatively steadily with downstream distance in the UBMC drainage. May 2001 loading trends through the concentrated tailings area near Shave Gulch uniformly increased for sulfate and all metals. Flow increase through this stream section is mostly attributable to inflow from Shave Gulch. Shave Gulch concentrations are low, suggesting the observed load increases are due to seepage from the concentrated tailings area and/or inputs from groundwater. The elevated concentrations in seepage samples indicate seepage impacts are likely the primary loading source.

Similar to the April 2001 monitoring event, iron and sulfate loads showed an appreciable increase through the natural upper marsh. In May 2001, a site was established and sampled on Meadow Creek. The results obtained suggest that Meadow Creek is not a significant source of metals or sulfate loading to the Blackfoot River.

In general, the May metals and sulfate concentrations are an order of magnitude lower than the corresponding April concentrations, but metals and sulfate loads in the upper Blackfoot River are generally higher in May than in April because of the higher May flow rates. In Beartrap Creek and Mike Horse Creek, April loads were generally higher than the May loads, despite the lower flow rates in April.

June 2001

The June 2001 seasonal monitoring event was postponed to allow flows to stabilize after a high flow “storm event”. Two samples were collected on June 18 for total recoverable metals analysis to allow comparison of this “storm event” period with the subsequent June synoptic monitoring.

Stream flows on June 18 were approximately twice those on June 25. Concentrations of metals were similar on both dates, although generally higher on June 18 during the higher flow period. Thus, in-stream loads were about twice as high on June 18 as on June 25. These results suggest that loads and concentrations of metals in UBMC surface waters respond directly to spring storm events and that loading at this time of year is principally controlled by flow.

Loading trends in June 2001 were similar to those observed during May 2001, with relatively steady increases in loads of sulfate and most metals throughout the drainage. During June, the increases were mostly confined to the upper reach of Mike Horse Creek with less impact through the lower reach. Loads of sulfate and all metals again showed consistent increases adjacent to the concentrated tailings area near Shave Gulch. Similar to previous monitoring events, iron loads showed an appreciable increase through the natural upper marsh. Throughout the drainage, flow rates and loads were generally slightly lower in June than in May.

October 2001

The October 2001 monitoring data show the continued presence of a metals and sulfate source in upper Mike Horse Creek. The largest increases in concentration observed in October generally occurred along upper Mike Horse Creek and zinc and manganese increased slightly through Beartrap Creek. Due to low stream flows, the effect of the wetlands treatment system discharge on in-stream sulfate and zinc loads was greater than during spring monitoring events.

Loads of sulfate and all metals (except iron and manganese) again showed consistent increases adjacent to the concentrated tailings area near Shave Gulch. Numerous “spikes” in lead loading were again present, suggesting multiple sources followed by areas where lead is removed. The iron load increase through the natural upper marsh persisted.

In general, the concentration and loading trends indicate the primary loading sources are present in Mike Horse Creek, with the significance of downstream sources varying through the year. The loading of iron through the lower marsh appears significant and consistent.

Comparison of the October results to those from April, May and June indicates that both the concentrations and the loads of metals and sulfate are lower in October than at other times of the year.

3.2.4 2007 DEQ Surface Water Sampling

Surface water was sampled at 27 locations including 17 existing sites which had been sampled by others during previous work. **Figure 3-6** shows the sample locations and **Table B-8** (in **Appendix B**) presents a sampling summary that specifies why each sample location was selected and included in the 2007 investigation. Sampling occurred in October 2007 to obtain data representative of low flow conditions and was performed in conjunction with streambed sediment and macroinvertebrate sampling at select sites (**Table B-8**). Surface water sampling locations were located in reaches where data review indicated potential loading could impact water quality. In general, sampling locations were located upstream and downstream of tributaries of the upper Blackfoot River. Samples were also collected in areas where only a few samples had been collected historically and in areas representative of background water quality.

In addition, field personnel attempted to locate well BMSP-2, a potentially flowing exploration well, within the Upper Marsh, while sampling other surface water locations. However, three crews collecting samples in the marsh were unable to locate the well. The well has likely been abandoned.

Surface water sampling and flow measurements occurred in accordance with Tetra Tech standard operating procedures. This work generally consisted of measuring field parameters at the sampling station, filling and preserving sample bottles for submittal to the analytical laboratory for the analyses listed in the 2007 SAP, and measuring flow using an area-velocity method. A timed volumetric flow measurement was made at two stations where water flowed through a pipe (AW-003A) or culvert (BRSW-108). It should be noted Stevens Gulch was a losing stream during the 2007 sampling event and did not reach the Blackfoot River. For this reason, the proposed sampling location (BRSW-108) was moved upstream to the point where the creek crosses the Paymaster access road in a culvert. Flow ceased approximately 100 feet below the road crossing.

Constituents exceeding Montana water quality standards were identified in the DSR as the basis for the 2007 analytical parameters list. Tetra Tech anticipates that the 2007 samples were collected in a similar manner and analyzed by the same or similar analytical methods such that the 2007 data are comparable with historic sampling. Montana water quality standards for metals (except aluminum) in surface water are based upon the analysis of samples following a “total recoverable” digestion procedure. As per Montana water quality standards, aluminum was filtered and analyzed as dissolved, but only when the surface water sample was within a pH range of 6.5 to 9.0. Field parameters measured during the sampling effort included dissolved oxygen, specific conductance, pH, and water temperature. Surface water samples were analyzed at the analytical laboratory for physiochemical parameters, total metals, dissolved aluminum, common cations, and common anions according to the 2007 SAP (Tetra Tech 2007). Samples collected for dissolved aluminum were filtered in the field through a 0.45-micron disposable in-line filter using a peristaltic pump then preserved as required. **Table B-9** in **Appendix B** presents the surface water analytical results.

Data Gaps Identified

Comparison of the 2007 surface water sampling data to Montana water quality standards and to earlier historical data will be evaluated once the 2007 sampling data is available.

- The 2007 surface water sampling included additional sampling locations intended to fill identified gaps in the existing surface water data set. Details of the locations and purposes of the additional sampling points were presented in the SAP (Tetra Tech, 2007). Inspection of other known historic mining features, such as the Calliope Mine in upper Shave Gulch, or discovery of other recently identified mining waste in the UBMC including some adits with discharges, and other currently unidentified historic mining features that are potential sources of contaminants to surface water could result in identification of additional data gaps in the surface water data set. However, at this time and for the purposes of this RIWP, except for the minor data gaps listed below, the surface water data set appears to be sufficiently complete. Identified surface water data gaps include the following: Surface water quality samples should be obtained upstream and downstream of the historic Calliope Mine in Shave Gulch to identify potential effects of that mine on Shave Gulch Creek, and
- Quarterly (seasonal) surface water monitoring should continue through at least 2008 to augment the existing surface water data set.
- Mine wastes were identified in drainage bottoms during the mine inventory performed during the 2007 investigation. Some of these wastes appeared to have the potential to impact surface water through direct contact and/or dissolution and mobilization from precipitation. Surface water above and below these areas should be sampled to evaluate potential impacts to surface water from these wastes.

3.3 STREAMBED AND MARSH SEDIMENTS

3.3.1 Historic Streambed Sediment Sampling Sites

Sampling and analysis of streambed sediments at the UBMC has been conducted at irregular intervals over the past 15 years or more to achieve various objectives. A summary of these sampling events and their results is provided in the DSR. Analytical data for the samples are provided in appendices of that report. Streambed sediment samples were typically analyzed for total acid soluble metal concentrations; however, a limited number of samples were analyzed for additional constituents such as cyanide and total organic carbon. As discussed in the DSR sediment data are difficult to compare between researchers because of differences in sampling techniques and temporal changes in sediment transport and deposition.

Table B-10 in **Appendix B** summarizes historic sediment sampling and analyses by tributary. In many cases “unknown” is listed for sample numbers. This is because: 1) while most sediment sample locations are reported in the DSR the lab reports and/or original documentation for the data have not been cross referenced to determine whether samples were collected from multiple depth increments at a given location; 2) multiple researchers collected samples from identical locations yet used different location numbers in their sample identifications, and 3) data for some sample events discussed generally in the text have not been located in analytical reports in order to confirm the number of samples. These discrepancies can likely be rectified following review of the original reports.

A portion of the analytical data indicated to be total metal concentrations (typically reported in units of mass of metal per mass of solid) in the DSR have units of milligrams per liter in the analytical laboratory reports. It is unclear whether a typographical error exists on the laboratory reports or whether a different type of analysis was performed.

3.3.2 2007 DEQ Streambed Sediment Sampling

Streambed sediments were collected at 21 of 27 surface water stations sampled during the 2007 sampling event. **Figure 3-6** shows the 2007 streambed sediment sampling locations. Samples were collected from the 0- to 2-inch depth interval using a stainless steel trowel to scrape the surface of the stream bed. Where possible, samples were also collected from deeper depth intervals (i.e. 2- to 6-inches and 6- to 12-inches) by excavating a pit in the stream bed with a shovel. All sediment samples were sieved through a 2 millimeter (10-mesh) screen prior to placing them in sample jars for shipment to the analytical laboratory for analysis of total metal concentrations (arsenic, cadmium, copper, manganese, mercury, lead, zinc). **Table B-11** in **Appendix B** presents the analytical results for sediment samples collected at surface water sampling locations.

3.3.3 Results of Streambed Sediment Sampling

Overview of Sediment Chemistry Data

Data for historic sediment samples show that metal concentrations are generally highest in upstream areas of the UBMC, near the historic mine facilities. Maximum sediment concentrations were observed in Mike Horse Creek, Beartrap Creek (downstream of the confluence with Mike Horse Creek), and the upper portion of the Blackfoot River (upstream of the first natural marsh). The historic results indicate that the metal concentrations in these sediments have decreased with time (DEQ 2007). Data for samples collected in 2007 will be integrated with the historic dataset and will be used to determine whether these historically observed trends remain under current conditions. In addition, metals data will be used to identify areas of sediment deposition for potential removal or other reclamation activities.

Spatial Trends

Geochemical data for sediment samples, particularly total metals data, will be compared to the historic dataset to determine whether sediments with elevated metal concentrations have been transported further downstream in the time since earlier investigations were conducted. In addition, sediment samples were collected in 2007 from areas not previously sampled.

Data Gaps Identified

It will be necessary to gain a better understanding of the sample locations and the results of historic sediment sampling in order to evaluate how this data might be integrated with or used with the 2007 sample data. Lab reports and/or original documentation for historic samples must be reviewed to determine whether samples were collected from multiple depth increments at a given location and to reconcile different sample location identifications used by various investigators over time. It will also be necessary to determine the origin of data reported in Table A-3, Appendix A of the DSR (DEQ 2007) because the units of measurement reported for these data do not appear to represent total metal concentrations as indicated in the text of that report. Furthermore, it is unlikely that the historic data represents current conditions at the UBMC Facility as various reclamation activities has gone on over the years including very recently. In all likelihood the 2007 suite of sediment samples collected should provide a more accurate evaluation of the current conditions in areas where historical data is very old.

A subset of the 2007 streambed sediment samples will be analyzed using ABA and SPLP metal mobility testing based on the initial metal concentration results. These data will be compared to guidelines to evaluate potential impacts from sediment in and near surface water. If data for sediment samples indicate the potential need to excavate contaminated material, the approximate volume and area of sediment depositions must be determined. For many areas, these data can be generated from data collected during the 2007 sampling event.

Screening and Ranking

Areas of sediment deposition will be screened and ranked according to their potential risk to human and ecological receptors and the environment. Ranking will be based on geochemical data, volume of contaminated sediment, proximity to surface water (for stream bank deposits), proximity to environmental receptors, potential routes for human exposure and the potential to leach metals to surface and groundwater. Detailed description of the ecological risk assessment is provided in Section 4.6.

3.4 MARSH SAMPLING

3.4.1 Historic Marsh Sediment Sampling

Sampling and analysis of streambed sediments at the UBMC has been conducted at irregular intervals over the past 15 years or more to achieve various objectives. Eleven studies in all investigate streambed and bank sediments employing different sampling protocols; however, only one of those studies, a study by Hydrometrics (DEQ 2007), collected samples in the Upper Marsh and Lower Marsh. This study was completed before any reclamation activities in the Upper Blackfoot drainage occurred and provides a qualitative means of comparison between pre- and post- reclamation conditions in the Upper Marsh. Sampling methods and sample sites were not identical between the earlier studies and those conducted by DEQ in 2007, but the data collected in 2007 should provide the basis for a comparative study of pre- and post-reclamation conditions in the Upper Marsh, in addition to providing data for the evaluation of data gaps and remedial planning. **Figure 3-8** shows the approximate location of the 1992 sampling locations.

Hydrometrics (as reported in DEQ 2007) sampled sediments at 16 locations in the Blackfoot River channel and marsh system in August 1991 and ten additional sites in December 1991 as part of a general site characterization study. The purpose of the 1991 sediment sampling was to characterize both fine-grained sediments and the oxide coatings on the larger sediment size fraction, and to identify and locate tailings sediments transported downstream as a result of the 1975 breach of the Mike Horse Tailing Impoundment dam.

Marsh sediments in the 1991 study, were collected by hand augering through marsh sediments (organic matter, silt, channel gravels, etc.). A visual inspection of sediments was conducted in the field to identify pyrite-bearing tailings, and bulk composite sediment samples were collected and submitted for laboratory analysis (samples were not sieved to a specific size fraction). Sediments were analyzed for total metal content of aluminum, arsenic, cadmium, copper, iron, manganese, nickel, lead, titanium, and zinc.

The visual inspection of sediments showed a high concentration of pyrite in samples collected at the upstream end of the uppermost marsh (Upper Marsh) on the Blackfoot River. The high concentration and layering of tailings material suggested deposition during a single event (i.e., the 1975 tailing dam breach). Pyrite-bearing tailing concentrations appeared to decrease rapidly through and downgradient of the marsh.

Metals concentrations in these sediments exceeded typical background concentrations at many river and marsh sampling locations. Elevated sediment concentrations of lead, manganese, and zinc persisted downstream into the second marsh system along the upper Blackfoot River. The highest iron concentrations (164,200 ppm) were noted in a pyrite-rich sample from the head of the uppermost marsh. Analysis of coarse-grained sediment from Mike Horse Creek coated with iron-oxyhydroxide precipitate showed elevated concentrations of arsenic, cadmium, copper, iron, lead, manganese, and zinc, suggesting that co-precipitation and adsorption of metals occurs in the headwater reaches of the Blackfoot River as iron-bearing mine effluent is oxidized and iron precipitates out of solution.

3.4.2 Fall 2007 Investigation

Tetra Tech completed sediment sampling in the Upper Marsh to evaluate potential tailings deposition in the marsh from the 1975 tailing impoundment breach, evaluate human health and ecological risk associated with possible tailing deposition in the marsh, and evaluate potential impacts to water quality in the Blackfoot River. **Figure 3-8** shows the marsh sediment sample locations.

The Upper Marsh sampling effort was based on a grid overlay consisting of 500-foot by 500-foot grid squares and a 250-foot by 250–foot subset grid. The grid resulted in 25 Upper Marsh sediment sample locations and two Pass Creek Marsh background sediment sample locations (**Figure 3-8**). Sediment samples were collected by completing hand dug test pits using a shovel.

Hand dug test pits were excavated to an average depth of about 30 inches and samples were collected beginning from the top of the mineralized sediment interface (i.e. beginning at the base of the current vegetative root layer) to 2 inches (0-2 inches), 2-6 inches, 6-12 inches. The 0- to 2-inch depth interval was collected to evaluate the potential risk to human health by direct exposure pathways. The remaining depth intervals were collected to evaluate the risk to human health, and also potential risk to ecological receptors, evaluate stratigraphic differences with respect to tailings and metals deposition, and evaluate areas of potentially elevated metals concentrations in preparation of a review of potential remediation efforts.

The sampling effort resulted in the collection of 79 sediment samples which were analyzed for saturated paste pH, electrical conductivity, total organic carbon, and total metals (arsenic, cadmium, copper, lead, manganese, mercury, and zinc). In addition, 35 of the marsh sediment samples were submitted to the laboratory for ABA and SPLP analysis to evaluate potential leaching ability of metals from the soil. **Table B-12** in **Appendix B** presents the analytical results for the marsh sediments.

Field observations noted the sample location, the visual presence of mine waste, sample color, and the presence of any unique features. A photograph of the location of each hand-excavated test pit location was taken with visual reference to surrounding topography when possible. The Upper Marsh is characterized by a yellow willow/sedge dominated community. The complex hydrology of the area is expressed as ponding, sub-irrigated saturated soils, and floating vegetation mats intermingled with dryer sites supporting limited spruce and lodgepole pine. The marsh vegetation community has high vigor and visually shows little sign of vegetation impact by metals. The average root mat ranged from 6 to 12 inches thick. Gray (chemically reduced) clays were encountered in the excavated sediments with high concentrations of pyrite. Impacted Upland areas with impacted vegetation were encountered adjacent to, and some distance from the stream channel. These areas, while not extensive, were devoid of vegetation and appeared to have high concentrations of tailings material. The sample grid included one of these locations.

Two areas along the Blackfoot River were observed where the water exhibited a milky color and a white chemical precipitate and staining on the substrate, often associated with high aluminum content. In addition, streambank soil lenses with high iron content were observed contributing iron-oxide or hydroxide coatings to the substrate in the river.

3.4.3 Background Sediment Sampling – Pass Creek Marsh

Two background sediment samples were collected to evaluate background metals concentrations in Pass Creek Marsh sediment for comparison with the Upper Marsh sediment samples collected during this investigation. The sediment samples, PDBG-1 PDBG-2, were collected from the 0- to 2-inch, 2 to 6-inch, and 6 to 12-inch depth intervals at the locations shown on **Figure 3-7**. The samples were collected consistent with the methods described above for sampling in the Upper Marsh. **Table B-12** in **Appendix B** presents the analytical results for the Pass Creek Marsh sediment samples.

3.4.4 Results of Marsh Sediment Sampling

Spatial distribution and concentration of contaminants in Upper Marsh sediments will be presented following interpretation of the 2007 sample results. Horizontal and vertical extent and concentration of contaminants will direct the selection of additional sampling points to better define the spatial distribution of impacted marsh sediment.

3.4.5 Data Gaps Identified

Based on the results of the 2007 Upper Marsh sampling event additional grid-based sample locations may be identified. These additional sample locations would assist in determination of the horizontal and vertical extent of impacted marsh sediment.

3.5 GROUNDWATER

3.5.1 Background Groundwater Quality

Few data are available from wells in areas representing background groundwater quality unaffected by mining activities at the UBMC. Wells and piezometers considered to represent background groundwater quality include well ANMW-9 completed in the alluvium along Anaconda Creek upstream of the confluence with Beartrap Creek and piezometers PMPZ-4 and PMPZ-5 completed in alluvium along the middle to upper reaches of Paymaster Creek above historic mining activity. The locations of the wells are shown on **Figure 3-9** and summarized in **Table B-13** in **Appendix B**.

Metals detected in groundwater from well ANMW-9 include one sample in which dissolved iron and manganese were present at concentrations slightly above detection limits (0.096 and 0.018 mg/L, respectively). Sulfate concentrations have been 10 mg/L or less, and the pH has ranged from 6.49 to 7.66. Groundwater from PMPZ-5, aside from containing aluminum at a concentration just above the detection limit (0.06 mg/L) and slightly higher sulfate concentrations (11 to 22 mg/L), is similar in quality to groundwater from well ANMW-9. However, the groundwater quality at piezometer PMPZ-4, farther downstream along Paymaster Creek than PMPZ-5, exhibits detectable copper (0.01 mg/L), higher concentrations of aluminum (0.72 to 1.7 mg/L), manganese (0.22 to 0.27 mg/L) and sulfate (40 to 46 mg/L) and lower pH (4.39 to 4.45) than groundwater from PMPZ-5. This well shows an impacted chemical signature in this portion of Paymaster Creek.

One other well, ANMW-3, which is located downgradient from known sources of contamination, exhibits groundwater of good quality, as compared to Montana water quality standards, which appears to be unaffected by mining disturbances.

This well is located across the Blackfoot River from the Anaconda Mine site. Groundwater from well ANMW-3 exhibited trace metal concentrations near or below detection limits and sulfate concentrations of 30 to 56 mg/L. The alluvial groundwater at this location on the south side of the river may be influenced by discharge into the alluvium from adjacent bedrock and seepage infiltration from the river.

3.5.2 Historic Sampling Sites

Groundwater monitoring has been conducted since 1989 at the UBMC. The primary groundwater monitoring programs at the UBMC include:

- Limited groundwater monitoring performed in 1989 by Delta Engineering as part of an Abandoned Mine Site Groundwater Investigation at the UBMC;
- Groundwater sampling and aquifer testing in the upper Mike Horse drainage by MSE, Inc. as part of their clay-based grouting experimental project;

- A detailed study of metals uptake in wetlands plants performed by RRU and MSI (1988) in the marsh system downstream of the UBMC; and
- Regular groundwater monitoring performed in 1992 and 1993 (PTI 1994) and from 1994 to present by ASARCO under the Phase I RI and the annual monitoring programs.

More than 250 groundwater samples have been collected from approximately 40 monitoring wells and piezometers at the UBMC through 2004 by numerous entities, including the USGS, various State agencies, University of Montana, and various private entities. In addition to sample collection for analytical purposes, static water level and field parameters (pH, dissolved oxygen, temperature, specific conductance) have routinely been measured prior to sample collection.

These monitoring activities are summarized below by mine area and/or drainage area. Emphasis is placed on the ASARCO monitoring programs since the Phase I RI and annual groundwater monitoring programs collectively represent the most comprehensive and current groundwater monitoring database. Additional information is included based on individual detailed site studies.

Monitoring well and piezometer information including general location, total depth, screen interval, completion unit, and monitoring purpose for each well or group of wells sampled in 2007 at the UBMC are summarized in **Table B-14** in **Appendix B**. **Table B-5** presents a year-by-year summary of all groundwater monitoring conducted at the UBMC from 1989 through 2004, including sampling locations and months during which groundwater monitoring occurred. All sampling locations referenced are shown on **Figure 3-9**. Tetra Tech will put much of the following descriptive groundwater quality data into a comprehensive table format for the draft RI report.

Mike Horse Mine – Mike Horse Creek

A total of 12 monitoring wells (MHMW-8, MIGW-01, UMHMW-1D, UMHMW-1S, UMHMW-2D, UMHMW-2S, UMHMW-3, and MW-1 through MW-5) have been installed to characterize groundwater quality in the Mike Horse drainage over the period of 1989 through 2001. Well MIGW-01 was installed in 1989 in the lower Mike Horse drainage to document alluvial groundwater quality downgradient of the Mike Horse Mine site (Delta 1989). Monitoring well MHMW-8 was installed in the lower Mike Horse drainage in 1994 by ASARCO to monitor bedrock groundwater quality downgradient of the Mike Horse mine site. MHMW-8 was sampled semi-annually by ASARCO from 1994 to 1998 and in 2000 for common ions and dissolved metals. MIGW-01 was sampled in 1989 by Delta Engineering and in 2001 by ASARCO for common ions and select dissolved metals.

In 2001, ASARCO installed five wells in Upper Mike Horse drainage to evaluate the source and extent of acidic, metals-bearing seepage documented in this area. Previous investigations identified an area of acidic seepage at the base of two waste rock piles (Upper Mike Horse

Table 3-5
Summary of Groundwater Monitoring Conducted at the UBMC

Site	Year													Total # of Samples
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
UMHMW-1D										O	M,Jy,O	M,O	M	7
UMHMW-1S											M,Jy	M	M	4
UMHMW-2D										O	M,Jy,O	M,O	M	7
UMHMW-2S										O	M,Jy,O	M,O	M	7
UMHMW-3										O	M,Jy,O	M,O	M	7
MIGW-01										M,O				4*
MW-1		D												1
MW-2		D												1
MW-3		D												1
MW-4		D												1
TDMW-1										O	M,M,Jy,O	M,O	M	8
TDMW-2S										O	M,M,Jy,O	M,O	M	8
TDMW-2D										O	M,M,Jy,O	M.O	M	8
BTC-TP-1P											M,M,Jy			3
BTC-TP-7P										O				1
BTC-TP-8P										O				1
BTC-TP-9P										O	M			2
BFR-TP-3P											M,Jy			2
BFR-TP-11P											M,M,Jy			3
BFR-TP-12P											M,M,Jy			3
MPP-4	N	F,M,Au												4
EDMW-2	N	F,M,Au												4
EDP-1	N	F,M,Au												4
EDP-2	N	F,M,Au												4
ANMW-3	N	F,M	J,N	M	O									8
ANMW-7			J,N	M,O	M,O	M,O	M,O							10
ANMW-9			N	M,O										3
BCMW-10			N	M,O	M,O	M,O	M,O							9
PMMW-13					Au,O	M,O,N,D	Ja,M,Au,O,N	Ja,M	A,Ju,O	Ja,M,Ju,O	Ja			21

Table 3-5
Summary of Groundwater Monitoring Conducted at the UBMC

Site	Year													Total # of Samples
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
PMMW-14					O	M,O	Ja,M,Au,O	Ja,M						9
PMMW-15						O,N,D	Ja,Au,O,N	Ja	A,Ju,O	Ja,M,Ju,O	Ja			16
PMP-3	N	F,M,Au		M,O	M,O	M,O	Ja,M,Au,O	Ja,M						16
PMPZ-3				O	M									2
PMPZ-4				O	M									2
PMPZ-5				O	M									2
UCMW-11			N	M,O	M,O	M,O	M,O							9
LCMW-1	N	F,M,Au	J,N	M,O	M,O	M,O								12
LCMW-5	N	F,M,Au	J,N	M,O										8
LCMW-6D			J,N	M,O										4
LCMW-6S			N	M,O	M,O	M	M							7
LCMW-12D			N	M,O	M,O	M,O	M,O							9
LCMW-12S			N	M,O										3
RRU Piezometers	38 piezometers sampled multiple times in 1987 and 1988 (RRU, 1988).													102

Notes:
Ja=January; F=February; A = April, M = May, J=June, Jy = July, Au=August; O=October; N=November; D=December
All locations are shown on Exhibit 1 and described in Table 3-8.
* Also sampled in August and October 1989.

waste rock piles 1 and 4), and increasing metal loads in Mike Horse Creek through this area. Wells UMHMW-1D and UMHMW-1S constitute a complementary well pair (a deep well and adjacent shallow well) located uphill of the seepage area. Well UMHMW-1D is screened from 30 to 42.5 feet within bedrock and UMHMW-1S is completed in colluvium/fill material to a depth of 5 to 15 feet. Complementary well pair UMHMW-2D and UMHMW-2S is located in the area of seasonal surface seepage. UMHMW-2D is completed in bedrock at a depth of 14.5 to 19.5, and UMHMW-2S is completed in the overlying alluvium/fill at a depth of 6.5 to 11.5 feet bgs (**Table B-14** in **Appendix B**). These wells were installed for the explicit purpose of determining the source(s) of the metals-bearing surface seepage. The fifth well, UMHMW-3, is completed in shallow bedrock 10 to 15 feet bgs. UMHMW-3 is completed in non-mineralized argillite bedrock of the Spokane formation, whereas bedrock wells UMHMW-1D and UMHMW-2D are completed in mineralized bedrock associated with the Little Nell ore vein.

MSE (1997) completed an assessment of bedrock hydrogeology in the upper Mike Horse Mine area, focused in the vicinity of the Mike Horse Fault. The MSE investigation evaluated the local bedrock groundwater system and its possible interaction with the Mike Horse mine workings. As part of this investigation, MSE completed nine monitoring wells in the upper Mike Horse area (MW-1 through MW-9) in and around the Mike Horse Fault, encountering extensively fractured bedrock (quartz porphyry). Groundwater sampling included four monitoring wells (MW-1, through MW-4) to assess groundwater chemistry in the upper Mike Horse drainage. Groundwater samples were collected in December 1993 and submitted for analysis of pH, arsenic, copper, iron, lead, manganese, and zinc.

The upper Mike Horse area is the only area within the UBMC with adequate density of monitoring wells with similar completions to generate a potentiometric surface map. A potentiometric map of groundwater levels recorded in September 1994 revealed a depression centered on monitoring well MW-7 near where Mike Horse Creek crosses the Mike Horse Fault. The depression was interpreted to represent an induced flow gradient towards the underlying Mike Horse mine workings resulting from groundwater inflow to the workings.

MSE (1997) also conducted various aquifer tests in the upper Mike Horse area to determine bedrock hydraulic properties. Aquifer testing included pumping tests performed on monitoring wells and slug and packer tests performed on numerous drill core holes. Pumping tests were performed on wells MW-1, MW-2, MW-4, and MW-5. Based on the pumping test results, bedrock transmissivity in most cases varied from about 20 to 50 gallons per day/foot (gpd/ft) (about 2.7 to 6.7 ft^2/day). Based on the well screen lengths, which range from 20 to 30 feet, the corresponding hydraulic conductivity values range from about two gallons per day per square foot (gpd/ft^2) (0.27 feet per day) for wells MW-1 through MW–4, to about five gpd/ft^2 (0.67 feet per day) for well MW-5. The packer tests provided similar results for hydraulic conductivity as the pumping test results. Hydraulic conductivity in the more fractured bedrock zones were on the order of one to 10 ft/day, while the less-fractured bedrock farther from the Mike Horse Fault zone was one to two orders of magnitude less. The packer tests also revealed a decrease in bedrock hydraulic conductivity with depth. The slug tests performed by MSE provided slightly lower (but comparable) hydraulic conductivity values than those obtained from the pumping tests.

These hydraulic conductivity and transmissivity values are not atypical for fractured bedrock and represent a relatively low water transmitting capacity for the upper Mike Horse bedrock aquifer. Likewise, the storage coefficient values shown in **Table 3-6** which represent the volume of water release from a unit volume of aquifer in response to a unit decline in hydraulic head, are typical for fractured bedrock.

Table 3-6
Groundwater Characteristics in Upper Mike Horse Drainage from MSE Investigation

Well	Pumping Rate Gpm	Water Level Drawdown feet	Transmissivity from Drawdown gpd/ft	Transmissivity from Recovery gpd/ft	Storage Coefficient
MW-1	0.6	25.33	14	44	0.005
MW-2	1.5	21.50	51	24	0.005
MW-4	1.0	8.25	na	34	na
MW-5	2.5	11.30	na	31 to 300	0.00095 to 0.01

Source: DEQ 2007
Notes:
gpd/ft – gallons per day per foot
All data from MSE 1997

Groundwater quality within the Mike Horse drainage is highly variable, depending on location and well completion depth.

Mike Horse Tailings Impoundment Area

Three alluvial wells (TDMW-1, TDMW-2D, and TDMW-2S) have been installed at the toe of the Mike Horse Tailings Dam by ASARCO to evaluate shallow groundwater quality and potential for subsurface flow through the tailings dam or through the tailings pond bottom. Monitoring well TDMW-1 is completed to a total depth of 32 feet in unconsolidated alluvium. Sampling results from this well provide information on general groundwater quality downgradient of the dam and near the confluence of the Mike Horse Creek and Beartrap Creek drainages. Well pair TDMW-2D and TDMW-2S are located at the dam toe near the former Beartrap Creek channel. Well TDMW-2D is screened at a depth of 22 to 37 feet in alluvium immediately above the bedrock contact, while TDMW-2S is screened between 7 and 17 feet bgs in a mixture of alluvium and fill material. Sampling of these wells from 2001 through the present for common ions and dissolved metals indicates, with the exception of low concentrations of manganese and zinc, metal concentrations in the tailings dam monitoring wells are typically below laboratory reporting limits (Hydrometrics 2007). In contrast to the elevated metal concentrations present in certain surface seeps at the dam toe, elevated metal concentrations are not present in groundwater monitored by the nearby alluvial wells.

In addition, five wells (TDMW-3S/D, TDMW-4S/D, and TDMW-5) were recently installed along the west side of the impoundment by ASARCO in 2006. Three are completed in bedrock while two are completed in colluvium/alluvium. These wells were sampled in November 2006 and May 2007 for common ions and dissolved metals. Wells along the west side of the impoundment exhibit similar quality as those at the dam toe (Hydrometrics 2007). Groundwater levels near the tailings impoundment are generally lower than the tailings pond through most of the year, suggesting the pond is “perched” above the Beartrap Creek alluvial system. Thus groundwater is largely believed to flow through coarse alluvial sediments beneath the tailings and downgradient of the impoundment.

Beartrap Creek

Monitoring well BCMW-10 is located in the Beartrap Creek drainage upstream of its confluence with Anaconda Creek and is completed in alluvium to a depth of 16 feet. Well BCMW-10 was sampled from 1994 through 1998 by ASARCO for common ions and dissolved metals (**Table 3-5**).

Seven piezometers (BTC-TP-1P, BTC-TP-2P, BTC-TP-6P, through BTC-TP-10P) (**Figure 3-9**) were completed in the Beartrap Creek drainage by ASARCO in conjunction with the Beartrap Creek mine waste sampling program (Hydrometrics 2001). Piezometers BTC-TP7, BTC-TP8, and BTC-TP9 were sampled in 2001 and 2002 for common ions and dissolved metals.

Groundwater quality results for the Beartrap Creek monitoring well and piezometers are generally similar with the exception that the piezometers generally exhibited higher iron and manganese concentrations. Alluvial groundwater of the channel bottom appears to be well connected with surface water.

Anaconda Mine – Anaconda Creek

Three monitoring wells (ANMW-3, ANMW-7, and ANMW-9) were installed at the Anaconda Mine site (**Figure 3-9**). The reclaimed Anaconda Mine is the site of the constructed wetlands-based water treatment system, which currently treats drainage from the Mike Horse Mine and Anaconda Mine adits.

ANMW-3 was installed by ASARCO as part of the 1992/1993 Phase I RI (PTI 1994) downgradient (west) of the Anaconda Mine site and approximately 50 feet from the Blackfoot River. ANMW-3 is completed to a depth of 25.5 feet in alluvium. Monitoring wells ANMW-7 and ANMW-9 were installed at the Anaconda Mine in 1994. Monitoring well ANMW-7 is located adjacent to the Blackfoot River downstream of the constructed wetlands treatment site to a depth of 22 feet. Monitoring well ANMW-9 is located adjacent to Anaconda Creek upstream of its confluence with Beartrap Creek and is completed in alluvium to a depth of 20 feet. Monitoring well ANMW-9 was installed to provide background groundwater quality data in Anaconda Creek drainage.

Table 3-5 lists the sampling history for the Anaconda Mine area wells. ANMW-3 was sampled from 1992 to 1996, ANMW-7 from 1994 to 1998, and ANMW-9 once in 1994 and twice in 1995 in conjunction with reclamation planning and implementation. All wells were sampled for common ions and dissolved metals. Well ANMW-3 was also sampled for select total metals during 1992 and 1993. Upgradient well ANMW-9 exhibits good water quality with all trace metal concentrations near or below detection limits. Groundwater quality of this well likely represents alluvial underflow from the non-impacted Anaconda Creek drainage.

Monitoring results from ANMW-7 show the alluvial groundwater downgradient of the mine and treatment system to have moderate concentrations of metals and pH values ranging from 5.8 to 7.2. Trace metal concentrations are near or below detection limits for arsenic, iron and lead, with higher concentrations exhibited for zinc and manganese (average 3.5 and 3.18 mg/L, respectively). Sulfate concentrations at this well average 173 mg/L.

Alluvial groundwater at well ANMW-3 exhibits good quality with trace metal concentrations near or below detection limits and sulfate concentrations ranging from 30 to 56 mg/L. The better quality groundwater at this site as compared to ANMW-7 is most likely the result of ANMW-3 being located across the Blackfoot River from the mine and thus representing water quality associated with the alluvial aquifer and the river rather than influences of the mine.

Upper Blackfoot River Drainage

Groundwater monitoring in the upper Blackfoot River drainage bottom (between the Anaconda Mine and the Upper Marsh on the Blackfoot River) includes a number of shallow piezometers and monitoring wells. Monitoring activities include sampling of one well installed in the vicinity of the Mary P prospect and three wells near the Edith Mine during the 1992/93 Phase 1 RI (PTI 1994), and installation and sampling of shallow piezometers in an area of tailings near the confluence of Shave Creek and the upper Blackfoot River. Locations are shown in **Figure 3-9**.

One alluvial monitoring well (MPP-4) was completed in the vicinity of the Mary P prospect during 1992 as part of ASARCO's Phase I RI activities (PTI 1994). Monitoring well MPP-4 is completed in alluvium from 15 to 25 feet bgs. MPP-4 was sampled during 1992 and 1993 (Table 3-9) for common ions and select total and dissolved metals. Sample results from MPP-4 indicate relatively poor water quality with moderately elevated metals and sulfate concentrations and a pH of approximately 5. One sample exhibited elevated aluminum concentrations of 3 mg/l.

Three piezometers (BFR-TP-3P, BFR-TP-11P, and BFR-TP-12P) were completed in the Blackfoot River concentrated tailings area near the confluence of Shave Gulch (Hydrometrics 2002). All piezometers are completed in alluvium/tailings, with one-foot long screens extending to depths ranging from 4 to 5.5 feet bgs. Groundwater samples were collected from piezometers in the Blackfoot River drainage during three monitoring events in 2002 (**Table B-14** in **Appendix B**) and analyzed for common ions and select dissolved metals. Shallow groundwater in the Shave Gulch concentrated tailings area exhibits the poorest quality observed along the upper Blackfoot River. Groundwater in this area is generally characterized by pH less than 4 and elevated metals and sulfate concentrations. Concentrations generally peak during the spring when water levels rise.

Groundwater monitoring in the vicinity of the Edith Mine (upstream of the marsh) was conducted to assess groundwater quality in this portion of the Blackfoot drainage and near the Edith Mine waste rock piles. Groundwater samples were collected from three wells EDP-1, EDP-2 and EDMW-2 during 1992 and 1993 as part of the Phase I RI (PTI 1994). Although EDP-1 and 2 are designated as piezometers, no significant difference in construction of piezometers as compared to monitoring wells is evident. Piezometers EDP-1 and EDP-2 are completed in alluvium from 15 to 25 feet and 14.5 to 24.5 feet, respectively. Monitoring well EDMW-2 is completed from 15 to 25 feet and is located west of the former Edith Mine waste dumps adjacent to the Blackfoot River. Water samples were analyzed for common ions and select total and dissolved metals. Groundwater sample results from the vicinity of the Edith Mine indicate variable water quality with pH ranging from less than 4 (EDP-2) to approximately 7. Metal concentrations in this area are generally elevated for aluminum, copper, iron, manganese, and zinc.

Due to the generally coarse nature of alluvium through this reach and shallow depth to groundwater, alluvial groundwater and surface water are likely well connected with groundwater providing base-flow. Prior to 2007 no bedrock wells were located within the upper Blackfoot River drainage.

Stevens Gulch

No historic groundwater sampling has been conducted within the Stevens Gulch drainage prior to 2007.

Shave Gulch

No historic groundwater sampling has been conducted within the Shave Gulch drainage.

Paymaster Mine – Paymaster Creek

Four monitoring wells (PMP-3, PMMW-13, through PMMW-15) and two piezometers (PMPZ-1 and PMPZ-2) were installed at the Paymaster Mine for characterization of groundwater quality in the mine area and to evaluate natural water quality upstream of the mine. PMP-3 was completed downgradient of the mine in alluvium to a depth of 25 feet. Groundwater samples were collected from well PMP-3 between 1992 and 1999 for analysis of common ions, dissolved metals, and select total metals. Monitoring wells PMMW-13 and PMMW-14 were completed near the Paymaster Mine in 1996. Well PMMW-13 was completed across the alluvium-bedrock interface to a depth of 18 feet, and well PMMW-14 was completed to a depth of 22.5 feet within alluvium. These wells were sampled periodically between 1996 and 2002 for common ions and dissolved metals.

In 1997, a wetland treatment system was constructed to collect seasonal discharge from the Paymaster Adit. Well PMMW-15 was completed in alluvium downgradient of the Paymaster wetland system during 1997 to a depth of 11 feet and sampled periodically through 2002 for select dissolved metals. Piezometers PMPZ-1 and PMPZ-2 were installed in alluvium adjacent to Paymaster Creek and downgradient of the Paymaster mine waste repository; however, no historical data appear to be available for either piezometer.

Three additional piezometers (PMPZ-3, PMPZ-4, and PMPZ-5) were installed in alluvium in the upper Paymaster Creek drainage and were sampled in October 1995 and May 1996 for common ions and dissolved metals. Piezometers PMPZ-4 and PMPZ-5 are located upstream of all known mining disturbances in the upper Paymaster drainage, with PMPZ-5 being the furthest upstream. PMPZ-5 exhibits good water quality with neutral pH values and metals concentrations at or near detection limits. PMPZ-4, located downstream of PMPZ-5 and upstream of known mining activities, exhibits pH less than 5 with elevated aluminum and manganese concentrations. The furthest upgradient well (PMMW-14) is located between piezometers PMPZ-3 and PMPZ-4 upgradient of historic disturbance and exhibits a pH of 4-5 with elevated iron and manganese concentrations. Aluminum, copper, zinc and sulfate are present at moderate concentrations. Samples from PMPZ-3 show relatively similar water quality as PMMW-14.

Monitoring wells in the vicinity of historic mining (PMP-3 and PMMW-13) commonly exhibit pH less than 4 with elevated aluminum, iron, manganese, and sulfate. However, although PMP-3 exhibits the highest dissolved aluminum concentrations and the lowest pH of any Paymaster well, concentrations of iron, manganese, and zinc are actually lower than at upgradient wells PMMW-13 and PMMW-14.

Pass Creek

No historic groundwater sampling has been conducted with in the Pass Creek drainage.

Carbonate Mine – Swamp Gulch Area

Seven monitoring wells in the Swamp Gulch area were installed to monitor groundwater quality downgradient of the Carbonate mine waste repository and reclaimed Carbonate Mine area. Wells include LCMW-5, well pairs LCMW-6S/D and LCMW-12S/D, UCMW-4, and UCMW-11. LCMW-5 is located adjacent to US Highway 200 (adjacent to lower historic tailings pond) and is completed in alluvium to a depth of 19 feet. Groundwater samples were collected from LCMW-5 in 1992 and 1993, as part of the Phase I RI (PTI 1994). Groundwater monitoring continued from 1994 to 1995 as part of the annual monitoring program and has routinely been sampled for common ions, dissolved metals, and select total metals during the period 1992 through 1995. Comparison of pre-reclamation period (1992-1993) and post-reclamation period (1995) samples shows that, on average, dissolved metals concentrations decreased and pH increased slightly after reclamation.

Five monitoring wells (UCMW-11, LCMW-6S, LCMW-6D, LCMW-12S, and LCMW-12D) were installed at the Carbonate Mine reclamation site in 1994 to support reclamation planning and monitoring (**Table B-14** in **Appendix B**). Monitoring well UCMW-11 is located at the toe of the Upper Carbonate Repository and was installed by ASARCO to serve as an alternate downgradient monitoring point since UCMW-4 was dry. UCMW-11 is completed in fractured, moderately oxidized porphyry bedrock to a depth of 82 feet bgs, where first groundwater was encountered. Well UCMW-11 is a low yield well and typically goes dry during purging, which suggests that bedrock groundwater flux through the area is small. UCMW-11 was sampled between 1994 and 1998 for common ions and dissolved metals. UCMW-11 has shown poor water quality throughout the monitoring period, including prior to repository construction. Groundwater pH at UCMW-11 has ranged from 2.9 to 6.5. Average dissolved metal concentrations from 1994 through 1998 include 22 mg/L zinc, 88 mg/L manganese, 0.36 mg/L cadmium, and 91 mg/L iron.

Complementary monitoring well pairs LCMW-6S/6D and LCMW-12S/12D are located adjacent to and downgradient of the Lower Carbonate reclaimed area, respectively. Shallow well LCMW-6S is completed in alluvium to a depth of 9.5 feet, and well LCMW-6D is completed across the alluvium/bedrock interface to a depth of 18 feet. Groundwater samples were collected from these wells from 1994 to 1998 for common ions and dissolved metals. Well pair LCMW-6S and LCMW-6D, shows slightly acidic pH values (4.4 to 7.3). LCMW-6S exhibited very high metals concentrations when first sampled in 1994 and 1995, with metals concentrations decreasing drastically from 1995 to 1998. Well MW-6D, completed in alluvium/bedrock from 10 to 15 feet bgs, also exhibits elevated concentrations of some metals. LCMW-6D was last sampled in 1995, precluding comparison to the MW-6S trends.

Wells LCMW-12S and LCMW-12D were completed in alluvium to depths of 17 and 27 feet, respectively. Groundwater samples were collected from these wells from 1994 to 1998 for common ions and dissolved metals. Groundwater at LCMW-12S and LCMW-12D is low pH (3.1 to 5.4) and high in dissolved iron. Metal concentrations in LCMW-12D, which is completed in organic debris (peat), are similar to or higher than those in LCMS-12S (completed in alluvium at 7 to 17 feet bgs). Metal equilibriums between the groundwater and the organic material in which LCMW-12D is completed, likely account for the high metals concentrations in this well.

Upper Marsh

The Upper Marsh is located at the confluence of the upper Blackfoot River, Paymaster Gulch, Pass Creek, and Swamp Gulch. An alluvial monitoring well (LCMW-1) is located along the Blackfoot River downstream of the Upper Marsh.

In 1987 to 1988, RRU and MSI (1988) conducted an investigation to evaluate groundwater within a wetland downgradient of Swamp Gulch and the former Carbonate mine. During the investigation, surface water, groundwater, soil, and vegetation samples were collected and analyzed between May 1987 and January 1988. A total of 38 piezometers at 24 sites within the marsh system downgradient of Swamp Gulch were sampled. A total of 102 groundwater samples were collected and analyzed for metals and anions.

Their report notes that the shallow system (0 to 4 feet) is dominated by iron-calcium sulfate and calcium-magnesium bicarbonate water types, with the latter occurring primarily at sites near and presumably influenced by the Blackfoot River. The deeper system (up to 16 feet deep) showed much less variation in water type than the shallow system, with calcium-magnesium sulfate the dominant water chemistry.

Of the metals parameters analyzed in the RRU/MSI study, aluminum, cadmium, copper, iron, lead, manganese, zinc, and sulfate were elevated in the Swamp Gulch watershed due to drainage from the Carbonate Mine, which has since been reclaimed. Concentrations in the wetland area shallow groundwater were elevated above concentrations found in the mine drainage near the inflow point, and decreased both laterally and vertically from this point. RRU and MSI concluded that, at the time, the Swamp Gulch wetland area was at least partially effective in removing iron from the Carbonate Mine drainage. Although the RRU/MSI data provided a characterization of groundwater quality in the wetland area near the Carbonate Mine in 1987-1988, the reclamation work completed in the intervening period suggests that the RRU/MSI data are not representative of current site conditions.

Well LCMW-1 is located downgradient of the Swamp Gulch wetlands at the Meadow Creek bridge crossing and is completed in the alluvium adjacent to the Blackfoot River. Alluvial groundwater exiting the upper marsh system is likely well connected with surface water in this area. Groundwater samples were collected from LCMW-1 in 1992 and 1993, as part of the Phase I RI (PTI, 1994). Groundwater monitoring continued from 1994 to 1997 as part of the annual monitoring program and has routinely been sampled for common ions, dissolved metals, and select total metals during the period 1992 through 1997. Well LCMW-1 shows better water quality than other Carbonate area wells, with sulfate concentrations less than 100 mg/L, near-neutral pH values, and relatively low but detectable concentrations of dissolved metals. Comparison of data from LCMW-1 for the Carbonate Mine pre-reclamation period (1992-1993) and the post-reclamation period (1995-1997) shows that, on average, dissolved metals concentrations decreased and pH increased slightly after reclamation.

3.5.3 2007 DEQ Groundwater Sampling

During October 2007, 18 new monitoring wells were installed, developed, and sampled. Twenty-two existing wells were also monitored. **Figure 3-9** shows the new and existing locations monitored during October 2007 and **Table B-14** in **Appendix B** lists the justification for each location.

Groundwater sampling consisted of measuring depth to water in each well listed on **Table B-14**, measuring field parameters during the purging process, and collecting water samples using low flow sampling methodologies. The following subsections describe these elements.

Monitoring Well Installation

A total of 18 monitoring wells were installed to fill identified data gaps throughout the Facility at the locations listed in **Table B-14** and shown on **Figure 3-9**. Monitoring wells were installed according to Tetra Tech standard operating procedure (SOP)-16 and State of Montana requirements. A drilling firm subcontracted to Tetra Tech drilled 6-inch diameter boreholes using air rotary methods. Drill cuttings were collected every 10 feet or at changes in lithology in order to identify lithology and groundwater intervals encountered. Drill cuttings were disposed of in accordance with DEQ’s Purge Water Disposal Flowchart (criteria applied to soil instead of water). No mine waste or tailings were encountered during the drilling of new monitoring wells and therefore, drill cuttings were spread out and land applied in the vicinity of the well collar.

Monitoring wells were installed to evaluate both shallow alluvial groundwater and deeper bedrock groundwater. Many new well sites were co-located to provide shallow and deep monitoring well pairs. Wells were constructed of 2-inch diameter schedule 40 PVC with 0.020-inch slot screened sections. For bedrock wells, boreholes penetrated bedrock approximately 40 feet prior to completion with a screened interval of 15 to 20 feet in length in an attempt to intercept the greatest number of water yielding fractures. The screened interval was not allowed to “bridge” the bedrock-alluvium interface. Wells were completed with: 1) 10-20 silica sand to two feet above top of slotted casing; 2) bentonite seal from top of sand pack to within 1 foot of grade; and 3) a 2-foot steel lockable stick-up well protector set in concrete.

Eleven locations were completed within alluvium. Alluvial wells were constructed of 2-inch diameter schedule 40 PVC with 0.020-inch slot screened sections. The screened interval was a maximum of 10 feet in length (with the exception of one low yielding well receiving 20 feet of screen). Wells were completed with: 1) 10-20 silica sand to two feet above top of slotted casing; 2) bentonite seal from top of sand pack to within 1-foot of grade; and 3) a 2-foot steel lockable stick-up well protector set in concrete.

Monitoring wells were developed according to Tetra Tech SOP-17 using a surge and bail or surge and pump technique. Data from historically drilled groundwater monitoring wells in the UBMC has not encountered water with characteristics approaching those of a RCRA hazardous waste (with the exceptions of UMHMW-1S and UMHMW-2S groundwater wells, both of which are located in one highly contaminated area at the Mike Horse mine). In addition, none of the new monitor wells drilled encountered mine waste or tailings. Therefore, development water was disposed of according to DEQ’s Purge Water Disposal Flowchart and it was deemed appropriate to land apply the water produced during the development phases of monitor well construction to an area in the vicinity of the well collar in a manner that did not cause surface water discharge. Actual ground water quality from the wells drilled was subsequently analyzed to insure that the historical observations characterizing the water as non-RCRA waste are validated by the current drilling. Finally, each well was surveyed by a licensed surveyor registered in the State of Montana.

Groundwater Field Parameters and Groundwater Sampling

Field parameters measured in the field include pH, specific conductance, temperature, oxidation-reduction potential, dissolved oxygen, and depth to water. The 2007 SAP (Tetra Tech 2007) provides additional details regarding the field parameters and standard operating procedures.

Groundwater Sampling

The depth to water and total depth of each well were gauged prior to purging and sampling the well using an electronic water level probe. Purge water was disposed of according to DEQ's Purge Water Disposal Flowchart. For the reasons cited above in the Monitor Well Installation Section, purge water produced during sampling was land applied to an area in the vicinity of the well collar in a manner that did not cause surface water discharge. Actual ground water quality from the wells drilled was subsequently analyzed to insure that the historical observations characterizing the water as non-RCRA waste are validated by the current drilling. At the request of DEQ, the primary method of sampling included the use of a submersible low-flow bladder pump. However, if low-flow sampling method criteria could not be met (i.e., minimal water column in the well or inaccessible by vehicle), sampling was completed by hand bailing with a disposable polyethylene bailer. Samples for metals analysis were field-filtered through a 0.45-micron disposable in-line filter and collected in clean laboratory-supplied bottles in accordance with standard methods and procedures. The 2007 SAP provides additional details regarding sampling and preservation requirements for samples (**Appendix A**). Non-disposable sampling equipment was decontaminated between monitoring wells according to SOP-11 (Equipment Decontamination).

The groundwater samples collected during the 2007 investigation were analyzed for physiochemical parameters, metals (aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, and zinc), common cations, and common anions. The 2007 SAP presents a detailed list of parameters and analytical methods.

3.5.4 Results

2007 sample data is not available at this time. This section would briefly describe any significant differences between the historical groundwater data set and the 2007 sampling data and the implications of those differences. It will not repeat, but rather synthesize where necessary, the information provided above in Section 3.4.2.

Data Gaps Identified

Review of historical groundwater data and additional data gathered during 2007 reveals a number of data gaps that are listed and described below.

- Existing well ANMW-9 could not be located during the fall 2007 sampling event. That well should be either located or replaced so that groundwater quality in the alluvium along Anaconda Creek can be monitored.
- Paired wells, with one of the pair completed in alluvium and the other completed in bedrock beneath the alluvium, should be constructed in Shave Gulch. Recommended locations are near the mouth of Shave Gulch downgradient of the Consolation Mine, in Shave Gulch upstream of the Consolation Mine, and upstream and downstream of the Calliope Mine in the western tributary of upper Shave Gulch. These wells would allow assessment of groundwater flow and quality near the mentioned mines and just above the point where groundwater discharges from the Shave Gulch alluvium into the Blackfoot River alluvium.
- One set of paired wells should be constructed near the mouth of Pass Creek to allow assessment of groundwater flow and quality near just above the point where groundwater discharges from the Pass Creek alluvium into the Blackfoot River alluvium.
- Monitoring wells should be constructed in upper Stevens Gulch near the Capital Mine to help assess the effectiveness of reclamation in that area.
- Alluvial well BCGW-115 in the Beartrap Creek valley was to have been completed in bedrock to allow evaluation of the bedrock groundwater quality. A paired well completed in bedrock should be constructed adjacent to well BCGW-115.
- At least one monitoring well should be installed in the Mike Horse Mine workings. The well(s) would provide information on the water level in the workings and assessment of how effective the existing mine adit plugging has been at flooding the workings and preventing the exposure of the workings to the oxidizing environment above the water level. The well(s) would also allow future comparative monitoring of hydrogeologic conditions in the mine in the event that the flow-through bulkhead is converted to a water-tight plug and the adit is actually sealed to prevent through-flow.
- A similar well should be constructed in the Anaconda Mine workings.
- Aquifer testing should be conducted using existing wells in the Blackfoot River alluvium in two representative areas – one near wells MPP-4 and BRGW-110 adjacent to the Mary P prospect and one near wells LCMW-1 and BRGW-101 near the downgradient end of the project area. An alluvial well and a bedrock well are present in each area. The testing would include pumping of the alluvial well and monitoring of both the alluvial well and bedrock well during and following the pumping. Groundwater samples for water quality testing should also be collected during the early and late parts of the test. The testing would provide data on the hydraulic conductivity of the alluvial aquifer, which could be used in evaluation of the mass transport of contaminants through the alluvial aquifer. The testing should also provide at least limited data on the interconnection of the alluvial and bedrock groundwater systems in those areas.

Further evaluation of the middle reach of Paymaster Gulch should be made to provide additional information on the relation of the ferricrete deposits in that area to the Mike Horse Fault System or other structural features.

3.6 BENTHIC MACROINVERTEBRATE SAMPLING

3.6.1 Historic Sampling

Sampling for macroinvertebrates in the upper Blackfoot River drainage occurred in 2000, 2001 and 2003 (DEQ 2007). Sites sampled (years sampled are denoted in parentheses) within the drainage were located on the Blackfoot River (2000, 2001 and 2003) near the confluence with Shave Gulch, Blackfoot River (2001 and 2003) downstream of the confluence of Beartrap and Anaconda Creeks, and in Beartrap Creek (2001) upstream of the confluence with Anaconda Creek. Collections of the macroinvertebrate population generated estimates of benthic macroinvertebrate densities in a given location and allow for statistical comparisons with future sampling efforts. **Figure 3-10** show the location of the historic sampling locations and **Table B-15** in **Appendix B** presents the historic results.

Samples in the field were submitted to a qualified taxonomic laboratory to complete sample analysis. Laboratory processing included identification to the lowest possible taxonomic level and enumeration by taxon. A list of species was created in addition to data on relative abundance, number of taxa, dominant taxa, and percent dominant taxa. Analysis was performed to calculate biotic integrity indices, ratios of functional groups (scraper, shedder, and filtering taxa), ratios of EPT (*Ephemeroptera*, *Plecoptera*, *Trichoptera*) and *Chironomidae* taxa, tolerance quotients, tolerance values, and community similarity indices. Diversity was measured using the Shannon-Weaver Diversity Index (H'), which is recommended by the EPA to evaluate the effects of stress on invertebrate communities (Klemm et al. 1990). This diversity index generally has values ranging from 0 to 4, with values of less than 1 indicating severe stress and values greater than 2.5 indicating a healthy invertebrate community. EPT taxa include sensitive invertebrate groups such as *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies) (Klemm et al. 1990, Barbour et al. 1999) and their relative abundance indicates the amount of environmental stress present in the aquatic system.

Using the above taxonomic analyses, the potential for environmental pollution can be inferred for all sites sampled. By examining the data it is possible to determine if a site has predominantly low flow conditions, the type of substrate that is most likely present, the amount of metals that might be present, and the overall robustness of the system being sampled.

The Blackfoot River near the confluence with Shave Gulch sampled in 2000, 2001, and 2003 has consistently shown average habitat conditions throughout the three years that this sampling location was sampled. This can be inferred from the dominance of a few species and average diversity. The dominance of one order within the key EPT taxa shows that while strong populations of one of these orders are observed, the lack of strong populations of the other taxa may point to lower water quality. However, this sampling location has historically shown that water quality is better than average. The lack of some indicator species may indicate a stream that has a substrate that lacks sufficient interstitial space and poor water quality.

The sampling location on the Blackfoot River downstream of the confluence of Beartrap and Anaconda Creeks sampled in 2001 and 2003 has historically shown poor water quality, in comparison with Montana water quality standards. This can be inferred by the dominance of the sample from the order *Diptera* and the relative lack of EPT taxa that were captured. Species richness for this location was also relatively low which agrees with the average diversity index score. In addition of the dominance of *Diptera*, the dominance of the functional feeding group, gatherers indicates poorer water quality as well.

The sampling location on Beartrap Creek that was sampled in 2001 has shown perhaps the lowest water quality of any of the locations sampled based on the almost complete dominance of *Diptera* species and of gatherer species. Other taxonomic analyses also have shown poor water quality, in comparison with Montana water quality standards, with relatively low species richness and diversity index score. This location has only been sampled once, so a trend of inferred water quality cannot be determined.

3.6.2 2007 DEQ Aquatics Sampling

Data gaps that were identified prior to the 2007 sampling include the scarcity of intense sampling of macroinvertebrate communities downstream of potential impacts, definitive data about metal contamination within the stream column and the relative health of the primary producer community within the stream segments. To address the scarcity of sampling locations, several more sampling locations were added to the program within the upper Blackfoot River and tributaries, between large marsh areas, where possible, and downstream of the three marsh areas. To address the potential biological uptake of metals contamination within the macroinvertebrate community, samples of macroinvertebrates were collected and analyzed for tissue concentrations of selected metals. In order to further characterize the stream ecosystem, periphyton samples were collected in order to analyze for the abundance of Chlorophyll A and Ash Free Dry Mass (AFDM). The analysis for chlorophyll will help determine the relative abundance of green algae and other primary producers, while AFDM will give the relative abundance of vegetation in the stream channel.

Sample locations for the 2007 aquatics sampling are paired with select locations of the 2007 surface water and sediment sampling locations.

Benthic macroinvertebrate sampling was conducted in general accordance with the EPA Rapid Bioassessment Protocols and DEQ's Rapid Bioassessment Macroinvertebrate Protocols Standard Operating Procedure. In general, sampling consisted of taking thee qualitative subsamples from separate rock substrate riffles at each sample location, using a Hess or Surber sampler with 500-micron (μm) mesh. Each sample was collected by scrubbing larger rocks contained within the sampling apparatus and stirring the remaining substrate for a specified length of time. Benthic material disturbed and captured in the sampling apparatus was then transferred to a sample container. The three subsamples collected at each monitoring location were analyzed separately at the laboratory with the results combined to create a composite taxonomic analysis for each site sampled.

Laboratory processing of the samples included identification to the lowest possible taxonomic level and enumeration by taxon, providing a list of species including relative abundance, number of taxa, dominant taxa, and percent dominant taxa. The laboratory also calculated the biotic integrity indices, ratios of functional groups, ratios of EPT and Chironomidae taxa, tolerance quotients, tolerance values, and community similarity indices. Macroinvertebrate tissue was also analyzed for metals (arsenic, cadmium, copper, lead, manganese, mercury, and zinc). **Table B-15** and **Table B-16** in **Appendix B** present the results of the macroinvertebrate processing and metals analysis, respectively.

3.6.3 Results By Geographic Area

Laboratory results are not yet available. The results will be presented and discussed in the RI.

4.0 CONCEPTUAL MODEL OF CONTAMINANT MIGRATION

A discussion of the migration of contaminants is used to develop a site-wide conceptual model for the UBMC. The discussion identifies contaminants of potential concern (COPCs), source areas, release mechanisms, migration pathways, attenuation mechanisms, and describes a screening level approach to human and ecological risk-based exposure analysis.

These parameters are then used to generate graphical and descriptive conceptual models for contaminant migration at the project site. The conceptual site model is an integral part of the RI process that is the planning tool that organizes what is already known about the Facility and helps the planning team identify the additional information that must be gathered to make the decisions that will achieve the project's goals (EPA 2001).

4.1 CONTAMINANTS OF POTENTIAL CONCERN

Historical investigations summarized in the Data Summary Report (DEQ 2007) and more recent site investigations (for example the EE/CA prepared by Hydrometrics for ASARCO and the USFS (Hydrometrics 2007)) identify COPCs in the UBMC from mine wastes, soils, stream sediments and water as aluminum, cadmium, copper, iron, lead, manganese and zinc. In addition, arsenic may be identified as a COPC from soils and mine waste sources. The Data Summary Report (DEQ 2007) indicates that these potential contaminants are present at relatively high concentrations in some mine waste dumps and stream sediments within the UBMC and suggests that they are also present in oxidized environments in underground mine workings.

The COPCs described above affect the water quality in Mike Horse Creek, Beartrap Creek, and the upper Blackfoot River (above the Landers Fork) such that these stream segments are listed on DEQ's 303(d) list as having impaired beneficial uses for aquatic life, cold water fish, and drinking water supply. Beneficial uses are identified as impaired due to the following pollutants of concern for the Blackfoot River and Beartrap Creek: cadmium, copper, iron, lead, manganese, and zinc; with the addition of aluminum for Mike Horse Creek. These pollutants are released from areas containing historic mine wastes and adit discharges and in some areas may also in part be related to natural background conditions.

Abundant data are available demonstrating that these streams have at least a 17-year history of water quality impairment, including biological studies of Beartrap Creek, Mike Horse Creek, and the upper Blackfoot River above the Landers Fork. These studies indicated that these streams were moderately to severely impaired in the early 1990s in their ability to support aquatic life, primarily by the metals listed above.

4.1.1 Contaminant Persistence (by Media)

The final RI report will contain a discussion of the physical, chemical, and biological persistence of the contaminants of concern (COCs) within in each of the identified contaminated media types. Development of this discussion is premature here, as the final list of the COCs has not been identified and the importance and impact on various receptors of each of the COCs can not be delineated until the human health and ecological risk assessments have been completed.

4.2 PRIMARY AND SECONDARY SOURCES

The conceptual site exposure model (CSEM; **Figure 4-1**) contains several primary sources, or locations known to have directly received COPCs at the UBMC Facility. Additional sources, particularly outlying waste rock and adit discharges, will likely be identified as investigation of other potential source areas at the Facility continues.

4.2.1 Primary Sources

Primary sources of COPCs within the UBMC Facility include mine waste materials (waste rock and tailings) and transported and redeposited mine waste sediments located on both public and private lands. These mine wastes are sources of potential metals loading to surface water and groundwater. Primary mine waste sources identified in the UBMC Facility include:

- Mine waste rock piles and potential ineffectively reclaimed mine waste areas;
- Mine tailings (behind the tailings dam);
- Acidic metal-laden treated and untreated discharges from mine portals and adits; and
- Direct weathering of exposed (due to mining disturbance) vein and porphyry mineralization.

Discharges from Water Treatment Systems

Discharges from ASARCO's constructed wetland water treatment system, located at the former Anaconda Mine, is a known source of secondary contamination whose impact to the Blackfoot River system depends on the seasonal effectiveness of the system, the amount of water passing through the system, and the metals of concern. The system is notably less effective for dissolved zinc.

4.2.2 Secondary Sources

Secondary sources of contaminants are various media that become contaminated as a result of migration of the contaminants from the original release source.

Soils

Primary sources have the potential to contaminate surface and subsurface soil by leaching of metals and acidity. This leaching can, in turn, result in additional leaching of contaminants from the soil. Contaminated soil can also be transported on or off site by surface water erosion or as blowing dust.

Surface and Groundwater

Infiltration, percolation and leaching from primary sources can result in the dissolution of contaminants and the release of acidity that can migrate into surface and groundwater. Even low level contamination in the aqueous phases can pose a significant risk to ecological receptors.

Surface and groundwater flow can transport contaminants horizontally through streams/rivers and shallow unconfined alluvial aquifers to down-gradient on-site and potentially off-site locations, or vertically into the lower unconfined or deeper confined bedrock aquifers.

Marshes

Surface and groundwater chemistry has been documented as changing dramatically in marshes similar to the lower marsh on the UBMC Facility where the marsh acts alternatively as a sink and a source for metal contaminants probably due to changes in water levels and oxidation/reduction interfaces based on the time of the year (seasonally) and the metal of concern.

Erosion and Redeposition of Contaminated Sediments

Physical erosion, transport and redeposition of mine wastes by surface water can create zones or deposits of contaminated wastes. Deposits of this type have been identified at the UBMC Facility and include:

- Discreet deposits of relatively concentrated tailings;
- Intermixed and interbedded zones of alluvial materials and tailings;
- Fine-grained tailings dispersed throughout alluvial sediments;
- Surficial fine-grained over-bank deposits;
- Marsh sediments; and
- Recent in-stream sediments.

4.3 RELEASE MECHANISMS

Release mechanisms are the physiochemical processes that break down or release contaminants and cause them to move along migration pathways.

4.3.1 Run-off and Erosion from Mine Wastes

Surface water runoff and erosion of mine waste represents a common release mechanism for contaminants to surface water throughout the UBMC Facility. Erosion of mine waste by precipitation, storm water and snowmelt, and its subsequent release to surface waters, is evidenced by erosional gullies and alluvial sedimentary aprons present on the surface of, or near mine waste deposits. Waste deposits located adjacent or proximal to surface water are even more susceptible to erosion of the mine wastes, such as scouring and undercutting of mine waste deposits located in stream banks adjacent to active channels. Erosion of surficial materials (soils, mine wastes, etc.) has also resulted in secondary sources of contaminants that are located within stream sediments.

4.3.2 Oxidation of Sulfides

Metal COPCs are also made available for mobilization as products of sulfide mineral oxidation. Once freed from the mineral structure they can be leached from sources (mine wastes, tailings and exposed ore deposits) and then transported via acidic water to receiving streams and, in some places, to the area's groundwater system.

4.3.3 Metal Solubility in Water

The presence of acidic waters that commonly result from the oxidation of sulfides greatly enhances the solubility of metals in solution and allows the metals to migrate and accumulate in concentrations that can pose ecological or even human health risks, and then be transported as seepage from mine wastes, on or off-site in surface and groundwater.

4.3.4 Leaching and Infiltration by Storm Water

Infiltration of storm water (including snowmelt) and leaching of contaminants may also contribute to contaminant transport from sources into subsurface soils, surface water, and shallow groundwater. Sampling has shown native soils underlying the mine waste to depths of one to two feet also contain elevated concentrations of some metals, indicating leaching and redeposition of metals vertically into the soil profile from the mine waste sources.

4.3.5 Surface and Groundwater

Contaminants transported in solution or suspension in surface water can contaminate groundwater through surface water-groundwater interaction (i.e. losses to groundwater), and contaminated groundwater can contaminate surface water via these same interactions as it discharges through seeps and springs and as it contributes base flow to streams.

4.3.6 Wind Erosion

Contaminants can be eroded, transported and redeposited as particulates (fugitive dust) by wind erosion of dry non-vegetated mine waste of tailing material surfaces.

4.4 MIGRATION PATHWAYS FOR EXPOSURE

The principal migration pathways for exposure include surface water (including mine waste seepage and treated and untreated adit discharges), groundwater, erosion and sediment transport, and fugitive dust in air.

4.4.1 Surface Water

Migration pathways for contaminants to surface water are often identified by loading analyses that measure the impacts to receiving waters from known mine wastes, tributary stream inflows, treated and untreated adit discharges and, where possible, inflow to streams from groundwater. A site-wide surface water loading analysis has been conducted for the UBMC Facility using historical water quality data (see Section 3.2.3). The results of the loading analysis clearly indicate that contaminants are transported in surface water downstream to other on-site and off-site locations.

Mine Waste Seepage

Infiltration of precipitation and surface water can result in the mobilization of sulfide weathering oxidation products as seepage from mine waste facilities such as waste rock piles and tailings materials as well as from contaminated sediments that have been eroded, transported and redeposited along stream courses.

Adit Discharge

The oxidation of ore exposed in underground mine workings can be a source of contamination to groundwater that is commonly stored in the underground workings. This contaminated groundwater is often subsequently discharged from mine adits and portals into surface waters or infiltrates to groundwater in the area of the mine workings and is then carried in the groundwater system. In addition, the current operating system that treats adit discharge from the Mike Horse and Anaconda adits act as an additional sources to surface water. The treatment system is under-sized and does not meet water quality standards.

4.4.2 Groundwater

As with surface water, migration pathways of COPCs to groundwater can often be identified during loading analysis by documenting loosing reaches of streams (see Section 3.4.2) that can discharge surface water contaminants directly to groundwater. Contaminant migration can also result from direct discharge of seepage from mine wastes (waste rock and tailings), or direct discharges of contaminated water from underground mine workings to groundwater. In addition, contaminated groundwater can move though shallow alluvial aquifers and bedrock aquifers along traditional flow paths that can transport water down the hydrologic gradient across the Facility or even to off-site locations.

4.4.3 Erosion and Contaminated Surface Sediment Transport

Not only is erosion and surface sediment transport a release mechanism as is described above in Section 3.3, but this process also represents a significant migration pathway for the transport and redeposition of contaminants. The scope and scale of this pathway's operation at the UBMC Facility ranges from massive erosion, transport and deposition of large amounts of tailings from the failure of the Mike Horse Tailings Impoundment in 1975 largely present along Beartrap Creek and the upper Blackfoot River, but with finer-grained material having been deposited at least as far downstream as the marsh from that event. Subsequent erosion of these more massive upstream sedimentary tailings deposits has resulted in re-working of the sediments and their incorporation with other alluvial materials as either intermixed or disseminated tailings and alluvium deposits.

4.4.4 Air

Migration of contaminants can also occur in the form of fugitive dust from ineffectively revegetated reclaimed and unreclaimed mine waste areas (waste rock, tailings and stream sediments). Fugitive dust can potentially pose human health issues for recreationalists and workers in these areas.

4.5 ATTENUATION MECHANISMS

Contaminants of concern are attenuated by both natural mechanisms and constructed facilities at the UBMC Facility. Some of these mechanisms include:

- Sorption of metals on soil and mineral surfaces;
- Chemical precipitation as oxide and hydroxide complexes (i.e. ferricretes);
- Attenuation by sorption and precipitation in (natural and artificial) wetlands;
- Dilution with uncontaminated surface or groundwater; and
- Reduction of pH and metal solubility by buffering with alkaline solutions.

4.6 RISK ANALYSIS APPROACH

Data collected for this RI will be used in conjunction with previously collected data for the UBMC Facility to (1) estimate the human health and ecological risks associated with exposure to impacted environmental media at the UBMC facility, (2) identify the environmental media and chemicals that are primary human health and ecological concerns, (3) identify the environmental media and chemicals that pose little or no threat to human health and environment, and (4) provide a foundation for assessing the need for additional investigations and response actions for the UBMC Facility. Additional investigations may include additional data collection in an RI addendum. The following sections summarize the approach that will be used to assess human health and ecological risks for the UBMC Facility. Adjustments to this approach will be made, as necessary, based on the findings of the RI.

A preliminary CSEM was prepared to illustrate potential mechanisms of exposure for human and ecological receptors to impacted media at the UBMC Facility (see Figure 4-1). The preliminary CSEM is based on facility investigation data to date, and summarizes information on sources of chemicals at the UBMC facility, affected environmental media, chemical and release and transport mechanisms, potentially exposed human and ecological receptors, and potential exposure pathways for each receptor. The CSEM will be refined, as necessary, based on the findings of the RI. Details of the preliminary CSEM specific to human and ecological exposure are discussed below.

4.6.1 Human Health Risk Assessment

A baseline human health risk assessment (HHRA) will be conducted for the UBMC Facility, following completion of the RI for the facility. The HHRA will evaluate potential human health risks under current and future land use conditions, and will be prepared in accordance with MDEQ and EPA guidance. The general framework for an HHRA consists of the following five basic steps:

- **Conceptual Site Exposure Model:** This step involves identifying potential human receptors and potential pathways for receptor exposure to COPCs at the facility.
- **Data Evaluation and Identification of COPCs:** This step consists of evaluating facility data and identifying COPCs in sampled media.
- **Exposure Assessment:** This step involves quantifying receptor intake of COPCs for exposure pathways identified as potentially complete.
- **Toxicity Assessment:** This step consists of compiling toxicity values that characterize potential adverse health effects of exposure to COPCs.
- **Risk Characterization:** This step quantitatively characterizes potential risks to human health associated with exposure to COPCs.

The following sections discuss the general methodology that will be used for each of these steps of the HHRA. The data summaries, exposure assumptions, toxicity criteria, and risk calculations associated with these steps will be provided in the HHRA in EPA (2001) RAGS Part D tabular format. The specific methodology for the HHRA will be presented in the HHRA, and will be based on the results of the facility investigation tasks described in this work plan.

Conceptual Site Exposure Model

The first step of the HHRA involves identifying sources of chemicals at the UBMC Facility and affected environmental media, chemical release and transport mechanisms that may occur at the Facility, human receptor populations that may be exposed to the impacted media under current or future facility conditions, and potential exposure pathways for each receptor population. This information will be summarized in a CSEM. As discussed in Section 4.6, a preliminary CSEM was prepared for the UBMC Facility. The components of the preliminary CSEM specific to the assessment of potential human health risks are discussed below.

Sources of UBMC Chemicals and Affected Environmental Media: Sources of chemicals at the UBMC Facility and affected environmental media are detailed in Section 3.1 and Sections 4.2 through 4.4 of this work plan. Primary sources of chemicals at the UBMC Facility are mine wastes, and include mine waste rock piles, mine tailings, vein and porphyry exposed by mining activities, and acidic, metal-laden mine adit discharge, including treated adit discharge. Impacted media include soil (combined with mine waste in some locations), sediment, surface water, and groundwater.

For purposes of the HHRA, areas directly associated with UBMC chemical sources (that is, historical, active mining areas where these chemical sources originated) will be referred to as on-site exposure areas. Impacted areas located downstream from historical, active mining areas will be referred to in the HHRA as off-site exposure areas.

Chemical Release and Transport Mechanisms: Chemical release and transport mechanisms for the UBMC Facility chemicals are shown in **Figures 4-1** and **4-2**. Release and transport mechanisms include storm water runoff, infiltration and percolation, plant and subsequent food chain uptake (aquatic and terrestrial), and wind suspension (from wind erosion and vehicle traffic).

Potentially Exposed Human Receptors: Current land use at the UBMC Facility consists of dispersed recreational (on- and off-site) and dispersed residential (off-site) use. In addition, construction activities are currently ongoing at on- and off-site areas. Future land use of the UBMC Facility is likely to remain the same as current land use, with the addition of industrial land use. Although residential land use is currently limited to off-site areas, potential future on-site residential use will also be evaluated in the HHRA because there are no restrictions of the Facility for residential use. A residential land use scenario generally represents the greatest potential for exposure to site chemicals, and will provide information to support risk management decisions for on-site areas of the facility.

Each of the current and potential future land uses described above (recreational, industrial, residential, and construction) may occur in both on-site and off-site exposure areas of the UBMC Facility. Based on this information, the following current and future receptors will be evaluated in the HHRA (**Table 4-1**). The selection of recreational receptors listed below is consistent with MDEQ (1996, 2004) guidance for abandoned mine sites.

Table 4-1
Receptors Selected for Evaluation in the HHRA

Land Use	Receptor	On-Site		Off-Site	
		Current	Future	Current	Future
Recreational	Fisherman	X	X	X	X
	Hunter	X	X	X	X
	Gold Panner and Rock Hound	X	X	X	X
	ATV and Motorcycle Rider	X	X	X	X

Table 4-1
Receptors Selected for Evaluation in the HHRA

Land Use	Receptor	On-Site		Off-Site	
		Current	Future	Current	Future
Industrial	Industrial Worker		X		X
Residential	Resident (Adult and Child)		X	X	X
Construction	Construction Worker	X	X	X	X

Notes:
ATV All-terrain vehicle
X Receptor will be evaluated in the HHRA

<u>Potential Exposure Pathways</u>: A complete exposure pathway consists of four elements (EPA 1989). If any of these elements is missing (except in a case where the source itself is the point of exposure), then the exposure pathway is considered incomplete. Unless otherwise indicated, exposure pathways identified as potentially complete will be quantitatively evaluated in the HHRA. The four elements of potential exposure pathways include:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential human contact with the contaminated medium (referred to as the exposure point)
- An exposure route (such as ingestion) at the exposure point

Potentially complete exposure pathways associated with soil, mine wastes, and sediment at the UBMC Facility include ingestion, dermal contact, and inhalation of particulates released to outdoor air from wind erosion. These pathways are potentially complete for current and future recreational users, current and future residents, current and future construction workers, and future industrial workers.

Potentially complete pathways associated with surface water include ingestion and dermal contact. These pathways are likewise potentially complete for current and future recreational users, current and future residents, current and future construction workers, and future industrial workers.

Beneficial use for groundwater at the UBMC has not yet been classified because of the limited existing groundwater data for the facility. However, six private drinking water wells are located within one mile of the UBMC Facility (see Section 1.8.2). Therefore, for purposes of the HHRA, use of groundwater as a drinking water source will be assumed. Current and future residents may be exposed to chemicals in groundwater from ingestion as a drinking water source and dermal contact with groundwater during household use. Groundwater may also be used as a source of drinking water during future industrial use of the UBMC Facility. In addition, because the depth to alluvial groundwater is relatively shallow (less than 10 feet bgs in some areas of the facility), incidental ingestion of and dermal contact with groundwater are potentially complete exposure pathways for current and future construction workers. Because the quantity and frequency of contact by construction workers with groundwater is likely to be limited, these potential exposures will be qualitatively addressed in the HHRA.

Beneficial uses for surface waters within the UBMC Facility have been identified, and include contact during recreation, use for agricultural and industrial water supply, and use for drinking, culinary, and food purposes after conventional treatment (see Section 1.8.1). For purposes of the HHRA exposure associated with surface water will be assumed to be limited to ingestion and dermal contact during current and future recreational activities.

Metals contained in soil, mine wastes, sediment, and surface water are subject to food chain uptake by aquatic and terrestrial receptors. These receptors in turn may be consumed by recreational or residential receptors that are engaged in fishing or hunting activities. Health risks associated with consumption of fish and terrestrial wildlife by current and future fisherman, hunters, and residents will be qualitatively addressed in the HHRA. If sampling results indicate that bioaccumulation of metals detected in sampled media is likely, then quantitative evaluation of fish and wildlife consumption in the HHRA may be warranted.

Data Evaluation and Identification of COPCs

The second step of the HHRA involves reviewing the analytical results for samples collected for the RI to identify COPCs in soil/mine waste, sediment, surface water, and groundwater. For purposes of the HHRA, chemicals with estimated laboratory results (that is J-qualified data) will be assumed to be detected. Rejected (R-qualified) data will not be used in the HHRA.

As detailed in Appendix A, chemical analysis of soil and mine waste, sediment, surface water, and groundwater data will be limited to metals. Nine metals are targeted for analysis for each of these media: aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, and zinc. Metals that are essential human nutrients (calcium, magnesium, potassium, and sodium) will not be evaluated in the HHRA.

COPCs will be identified separately for each medium (for example, sediment) and each exposure area. For each medium and exposure area, analytical results for metals detected in facility samples will be compared with naturally occurring background concentrations. Metals that exceed background concentrations will be identified as COPCs for evaluation in the HHRA.

Exposure to naturally occurring, background concentrations of metals may also be associated with health risks; background risks will be qualitatively addressed in the HHRA.

Exposure Assessment

The third step of the HHRA involves quantification of exposure to the identified COPCs (that is, chemical intake) for exposure pathways that are potentially complete. This section describes the methods that will be used to estimate exposure point concentrations (EPC) and quantity chemical intake for each receptor.

Exposure Points and Exposure Point Concentrations

Potential exposure points are identified on the basis of current and anticipated future receptor activity patterns and the relationship of the activities to the presence of contaminated media. A location is identified as an exposure point if a human might contact (for example, ingest) a contaminated medium (for example, soil) at that location. Mine waste-impacted areas are shown in Figure 2-1. Twelve locations comprise these areas; each of these areas will be evaluated as a separate exposure point in the HHRA:

1. Anaconda Mine Waste Reclamation Areas and Waste Piles
2. Anaconda Mine Treatment Cells/Wetlands
3. Capital Mine Waste Pile
4. Carbonate Mine Waste Repository and Reclamation Area
5. Edith Area Waste Piles
6. Consolidation Mine Reclamation Area
7. Mary P. Mine Waste Pile
8. Mike Horse Mine Repository and Waste Piles
9. Mike Horse Tailings Impoundment and Associated EE/CA Removal Action Areas
10. Paymaster Mine Waste Areas and Repository
11. Stevens Gulch
12. Tunnel No. 3 Reclamation Area
13. Dispersed Tailings and Overbank Tailings Deposits Along Beartrap Creek and Blackfoot River from 1979 Tailings Dam Breech
14. Beartrap and Mike Horse Creek Surface Water and Streambed Sediment
15. Blackfoot River Surface Water, and Streambed and Marsh Sediment

Each of these locations will be evaluated as a separate exposure point in the HHRA. Soil/mine waste, sediment, surface water, and groundwater sampling locations will be assigned to each of these exposure points in the HHRA based on the proximity of the sampling location to the exposure point.

Exposure point concentrations (EPC) will be estimated from measured or modeled concentrations. Based on measured concentrations, EPCs for soil/mine waste, sediment, surface water, and groundwater will be calculated following EPA guidance (EPA 2000a, 2002a, 2002b, 2006, 2007a, 2007b). A 95 percent upper confidence limit (95UCL) will be used as the

EPC for each COPC, except when the 95UCL exceeds the maximum concentration or the data set is not sufficiently large to calculate a 95UCL.

Chemical release and transport mechanisms may result in transfer of COPCs from one environmental medium to another (for example, soil to air). In the absence of direct measurements of COPC concentrations in exposure media, fate and transport models provided in MDEQ (1996) and EPA (2002c) guidance will be used to estimate EPCs. In addition, metals in soil may leach to groundwater. To assess this potential, the HHRA will initially compare EPCs for COPCs in soil with EPA (2002c) soil screening levels for protection of groundwater. If soil screening levels are exceeded, then site-specific fate and transport modeling will be used to evaluate potential impacts to groundwater from leaching.

Chemical Intake Estimates

Estimates of chemical intake are based on the EPCs and on exposure scenario-specific assumptions and intake parameters. Chemical intakes will be calculated for each receptor and exposure pathway at each exposure point. Exposure assumptions will be based on MDEQ (1996 and 2004) and EPA (1989, 1991, 1997a, 2002c, 2004a) guidance, and will be detailed in the HHRA.

Toxicity Assessment

This step of the HHRA will involve compiling the chemical-specific slope factors (SF) and reference doses (RfD) that will be used to evaluate cancer risks and noncancer health effects, respectively, from exposure to COPCs. An SF is an upper-bound estimate on the increased cancer risk from lifetime exposure to a chemical. An RfD is an estimate of a daily exposure level that is likely to be without an appreciable risk of harmful effects. Toxicity criteria will be compiled for the HHRA based on the following hierarchy outlined by EPA (2003a):

- EPA's Integrated Risk Information System (IRIS). IRIS is an online database that contains EPA-approved RfDs and SFs (EPA 2007c). The RfDs and SFs have undergone review and are recognized as agency-wide consensus information.
- EPA's Provisional Peer-Reviewed Toxicity Values (PPRTV) Database, which is an online database that contains approved RfDs and SFs (EPA 2004b). The RfDs and SFs provided in the PPRTV Database have undergone review and are recognized as consensus information.
- Other EPA toxicity values, as presented in the EPA Region 9 preliminary remediation goal table (EPA 2004a).
    - EPA's Health Effects Assessment Summary Tables (EPA 1997a).
    - EPA's National Center for Environmental Assessment (NCEA) papers (chemical-specific references). NCEA provides guidance and risk assessments aimed at protecting human health and the environment.

- The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) toxicity criteria (OEHHA 2005, 2007). These toxicity criteria have undergone review and OEHHA is recognized by EPA (2003a) as a source of toxicity values for HHRAs.

An RfD or SF is not currently available for lead. If lead is identified as a COPC, then health risks from exposure to lead will be characterized separately.

Risk Characterization

The final step in the HHRA involves characterization of the potential risks associated with exposure to COPCs. This section summarizes the process that will be used in the HHRA for estimating cancer risks and noncancer hazards and for evaluating exposure to lead.

Characterization of Noncancer Hazards

The potential for exposure to result in adverse health effects other than cancer will be evaluated by comparing the chemical intake with an RfD for COPCs that are not classified as carcinogens and for those carcinogens known to cause adverse health effects other than cancer. When it is calculated for a single chemical, the comparison yields a ratio termed the hazard quotient (HQ). The HQs for all chemicals will be summed to yield a hazard index (HI). Pathway-specific HIs are then summed to estimate a total HI for each receptor. If the total HI exceeds 1.0, the threshold level for noncancer effects, further evaluation in the form of a segregation of HI analysis may be performed to identify whether the noncancer HIs are a concern.

Characterization of Cancer Risks

Risks associated with exposure to COPCs classified as carcinogens are estimated as the incremental probability that an individual will develop cancer over a lifetime as a direct result of an exposure. Three steps will be used to estimate cancer risks for COPCs classified as carcinogens. First, the chemical intake is multiplied by the COPC-specific SF to derive a cancer risk estimate for a single chemical and pathway. Second, the individual COPC cancer risks is assumed to be additive to estimate the cancer risk associated with exposure to multiple carcinogens for a single exposure pathway. Third, pathway-specific risks are summed to estimate the cumulative cancer risk. Cancer risks will be compared with the MDEQ allowable cumulative risk level of 1×10^{-5}.

Characterization of Risks from Exposure to Lead

The HHRA will evaluate the potential for health effects from exposure to lead in soil/mine waste and sediment by modeling blood lead levels and comparing modeling results to the EPA (1994) level of concern of 10 micrograms per deciliter. To evaluate residential exposure to lead, the EPA Integrated Exposure Uptake Biokinetic (IEUBK) model will be used (EPA 2004c). To evaluate nonresidential exposure to lead, the EPA Adult Lead Methodology (ALM) will be used (EPA 2003b).

The potential for health effects from exposure to lead in surface water and groundwater will be evaluated by comparing EPCs for lead with Montana Numeric Water Quality Standards for lead (MDEQ 2006).

4.6.2 Ecological Risk Assessment

A screening level ecological risk assessment (SLERA) for the UBMC Facility will be conducted in accordance with guidance from the EPA (EPA 1997b). A typical ecological risk assessment (ERA), following EPA guidance, is intended to fulfill three basic functions:

- Document whether actual or potential ecological risks exist at a site;
- Identify chemicals at a site that pose an ecological risk; and
- Generate data to be used to evaluate cleanup options, if necessary.

The ERA process is typically composed of the following eight steps (EPA 1997b):

- Step 1: Screening-level problem formulation and evaluation of ecological effects;
- Step 2: Screening-level preliminary exposure estimate and risk calculation;
- Step 3: Baseline risk assessment problem formulation;
- Step 4: Study design and data quality objectives;
- Step 5: Field verification of sampling design;
- Step 6: Site investigation and analysis of exposure and effects;
- Step 7: Risk characterization; and,
- Step 8: Risk management.

As specified by EPA guidance, Steps 1 and 2 of the ERA process is a SLERA or Tier I ERA in which the objective is to identify and document conditions that do not warrant further evaluation in a more refined baseline ERA (BERA). The goal is to eliminate insignificant hazards while identifying contaminants whose concentrations are sufficiently great as to potentially pose risks to ecological receptors. As defined by the EPA, a SLERA is a simplified risk assessment that can be conducted with limited data where site-specific information is lacking and assumed values are used to evaluate potential exposure and effects (EPA 1997b). For a SLERA, it is important to minimize the chances of concluding that there is no risk when in fact a risk exists. Thus, for exposure and toxicity or effect parameters for which site-specific information is minimal, assumed values, such as area-use and bioavailability, should be consistently biased in the direction of overestimating risk. This ensures that sites that might pose an ecological risk are studied further, i.e., a SLERA is designed to be protective in nature, not predictive of effects. If any potentially significant exposure pathways are indicated from the SLERA, then these pathways are further evaluated in a more refined BERA.

Preliminary Conceptual Site Exposure Model

At the screening level, exposure pathways are assumed to be complete to all ecological receptors (plants and animals) that potentially occur in the area. A preliminary CSEM for both aquatic and terrestrial habitats is provided in **Figure 4-1**. The preliminary CSEM illustrates potential exposure pathways to representative receptors (discussed below).

- Direct exposure to metals in wetland and stream sediment is assumed to occur at the Facility and thus represents a complete exposure pathway for aquatic plants and invertebrates, fish, and higher trophic level receptors.
- Direct exposure to metals in surface water is assumed to occur at the Facility and thus represents a complete exposure pathway for aquatic plants and invertebrates, fish, and higher trophic level receptors.
- Direct exposure to metals in soil is assumed to occur at the Facility and thus represents a complete exposure pathway for terrestrial plants and invertebrates, and higher trophic level receptors.
- Food-chain exposure of metals is assumed to occur at the Facility and thus represents a complete exposure pathway for higher trophic-level consumers that may reside at the site.
- The air exposure pathway is considered to be incomplete for inhalation of contaminated dust or vapors because most of the expected metals have low volatility.
- The groundwater exposure pathway is considered incomplete because ecological receptors are not likely to come into contact with groundwater.

Selection of Chemicals of Potential Ecological Concern

Surface soil samples collected at the UBMC in November 2007 will be evaluated to determine chemicals of potential ecological concern (COPEC). Concentrations of inorganic compounds in surface soil (between 0 and 0.5 feet below ground surface (bgs)) will be screened against surface soil concentrations representative of background locations as a first step in identifying COPECs for the SLERA. Inorganic chemicals will be retained as COPECs if they are detected in site samples at concentrations that exceed concentrations detected at representative background locations or that exceed literature-based screening levels.

Selection of Preliminary Assessment and Measurement Endpoints

EPA defines an assessment endpoint as an “explicit expression of an environmental value to be protected” (EPA 1997b). Various definitions of valuable ecological resources include those without which ecosystem function would be significantly impaired; those that provide critical resources, such as habitat or fisheries; and those perceived by humans as valuable, such as endangered species and other issues addressed by legislation. Useful assessment endpoints define both the valuable ecological entities at the site and a characteristic of the entity to protect, such as reproductive success or production per unit area.

Unlike a human health risk assessment, which evaluates only one species, an ERA evaluates multiple species with different degrees of exposure and toxicological responses. This assessment focuses on endpoints that are most likely to be affected given the fate and transport mechanisms of the COPECs, the ecotoxicological properties of the COPECs, the habitats at the site, and the potential aquatic and terrestrial receptors that exist at the site. The following are preliminary assessment endpoints that will be used to evaluate the potential ecological risk at the UBMC:

- **Aquatic plants** - Plants form the basis of the food web at the Facility, and adverse effects on the plant community could reduce the quantity and quality of food available to higher-trophic-level consumers. Therefore, the health of aquatic plants is considered an ecological value to be protected.
- **Fish and aquatic invertebrates** - Maintenance of sufficient rates of survival, growth, and reproduction to sustain the populations. Fish and aquatic invertebrates play an important role in nutrient cycling and in the food web at the Facility. Adverse effects on fish and aquatic invertebrates could reduce the quantity and quality of food available to higher-trophic-level consumers. Therefore, the health of invertebrates is considered an ecological value to be protected.
- **Terrestrial plants** - The health of terrestrial plants is considered an ecological value to be protected. Plants form the basis of the food web at the Facility, and adverse effects on the plant community could reduce the quantity and quality of food available to higher-trophic-level consumers.
- **Terrestrial invertebrates** - Maintenance of sufficient rates of survival, growth, and reproduction to sustain the populations. Terrestrial invertebrates play an important role in nutrient cycling and in the food web at the Facility. Adverse effects terrestrial invertebrates could reduce the quantity and quality of food available to higher-trophic-level consumers. Therefore, the health of terrestrial invertebrates is considered an ecological value to be protected.
- **Survival, growth, and reproduction of birds and mammals typical to the area.** Primary consumers and higher trophic level organisms may be exposed to elevated metals in water, soils, sediments, and lower trophic food sources. Adverse effects on birds and mammals could shift the composition of plant communities to annual species and reduce the quantity and quality of food available to higher-trophic-level consumers. Therefore, the health of birds and mammals typical to the area is considered an ecological value to be protected.

Assessment endpoints are not amenable to direct measurement; therefore, measurement endpoints related to assessment endpoints were identified. EPA defines a measurement endpoint as “a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint and is a measure of biological effects (such as mortality, reproduction, or growth)" (EPA 1997b). Measurement endpoints can include measures of exposure or effect and are frequently numerical expressions of observations. They may be compared statistically with a control or reference site or scientific study to detect adverse responses to a site-specific COPEC. Each measurement endpoint correlates directly with one of the defined assessment endpoints and is based on available literature regarding mechanisms of toxicity.

Measurement Endpoints for Preliminary Receptors of Concern

The following measurement endpoints will be used in evaluating potential ecological impacts on the preliminary assessment endpoints identified for the UBMC:

- **Aquatic Plants** - Comparison of the concentrations of chemicals in sediment with toxicity benchmarks for terrestrial plants. No benchmarks are available for aquatic plants. Therefore, chemical concentrations in sediment will be compared with Oak Ridge National Laboratory (ORNL) benchmarks for plants (Efroymson, et al. 1997a) and Eco-soil screening levels (SSL) for plants (EPA 2005). Plant benchmarks are provided on **Table 4-1**. Hazard quotients (HQ) will be developed by dividing the concentration in sediment by the plant benchmark. The Eco-SSL plant benchmark will be preferentially selected over the ORNL benchmark if benchmarks are available for both. Potential risk to aquatic plants will be indicated where HQs in site sediment exceed a value of 1.
- **Aquatic Invertebrates and Fish** - The following three measurement endpoints will be used to evaluate potential risk to aquatic invertebrates and fish:
    - Comparison of the concentrations of chemicals in sediment with toxicity benchmarks for aquatic invertebrates. Chemical concentrations in sediment will be compared with Probable Apparent Effects Thresholds (PAET) (Cubbage, et al. 1997). PAET and other sediment benchmarks are provided on **Table 4-2**. HQs will be developed by dividing the concentration in sediment by the PAET benchmark. Potential risk to aquatic invertebrates and fish will be indicated where HQs in site sediment exceed 1.
    - Comparison of the concentrations of chemicals in surface water with acute and chronic freshwater toxicity benchmarks. Chemical concentrations in surface water will be compared to chronic and acute criteria developed in compliance with the Montana Water Quality Act and Section 303(c) of the Federal Clean Water Act. The freshwater benchmarks are provided on **Table 4-3**. HQs will be developed by dividing the concentration in surface water by the DEQ benchmark. EPA benchmarks will be used where DEQ benchmarks are not available. Water quality criteria for cadmium, copper, chromium III, lead, nickel, silver, and zinc are hardness dependent.

- Macroinvertebrates will be collected and identified from locations that coincide with a surface water sampling station. Benthic community metrics including number of taxa, relative abundance, and ratios of functional groups will be calculated. Benthic community metrics from the Facility will be compared to reference site results.
- Macroinvertebrate tissue will be analyzed for metals from locations that coincide with a surface water and benthic community sampling station. The results will be evaluated to determine potential correlations between the other lines of evidence collected to evaluate risk to fish and aquatic invertebrates (sediment, surface water, and benthic community analysis). Tissue results from the Facility will also be compared to tissue data from the reference site.

- **Terrestrial Plants -** Comparison of the concentrations of chemicals in soil with toxicity benchmarks for terrestrial plants. Chemical concentrations in soil will be compared with ORNL benchmarks for plants (Efroymson, et al. 1997a) and Eco-SSLs for plants (EPA 2005). Plant benchmarks are provided on **Table 4-1**. HQs will be developed by dividing the concentration in soil by the plant benchmark. The Eco-SSL plant benchmark will be preferentially selected over the ORNL benchmark if benchmarks are available for both. Potential risk to terrestrial plants will be indicated where HQs in site soil exceed 1.

Table 4-2
Selected Soil Screening Levels for Ecological Receptors

	Eco-SSL Soil Screening Benchmark				ORNL Soil Screening Benchmark	
Analyte	**Avian (mg/kg)**	**Inverts (mg/kg)**	**Mammalian (mg/kg)**	**Plants (mg/kg)**	**Invertebrates (mg/kg)[a]**	**Plants (mg/kg)[b]**
Aluminum	--	--	--	--	--	50
Antimony	--	78	0.27	--	--	5
Arsenic	43	--	46	18	60	10
Barium	--	330	2000	--	--	500
Beryllium	--	40	21	--	--	10
Cadmium	0.77	140	0.36	32	20	4
Total Chromium III	26	--	34	--	0.4	1
Cobalt	120	--	230	13	--	20
Copper	28	80	49	70	50	100
Iron	--	--	--	--	--	
Lead	11	1,700	56	120	500	50
Manganese	4,300	450	4,000	220	--	500
Mercury	--	--	--	--	0.1	0.3
Molybdenum	--	--	--	--	--	2
Nickel	210	280	130	38	200	30
Selenium	--	--	--	--	70	1
Silver	4.2	--	14	560	--	2
Thallium	--	--	--	--	--	1
Vanadium	7.8	--	280	--	--	2
Zinc	46	160	79	160	100 [c]	50

Notes:

-- Indicates no value was reported.

Eco-SSL	-Ecological Soil Screening Levels	ORNL	-Oak Ridge National Laboratory
EPA	-U.S. Environmental Protection Agency	mg/kg	-Milligram per Kilogram

a ORNL invertebrate soil screening benchmarks are from Efroymson et al. (1997a).

b ORNL plant soil screening benchmarks are from Efroymson et al. (1997b).

c The online Risk Assessment Information System database (http://rais.ornl.gov/cgi-bin/eco/ECO_select), accessed October 3, 2007, shows an ORNL Plants Screening Benchmark value of 100 mg/kg; however, Efroymson et al., 1997b shows a value of 200 mg/kg.

Table 4-3
Selected Sediment Screening Levels for Ecological Receptors

Analyte	AET[a] (mg/kg dry weight) [b]	PAET [c] (mg/kg dry weight) [b]	(TEL)[d] (mg/kg)[e]	PEL[f] (mg/kg)[e]	UET[g] (mg/kg)[eh]	MAEL [i] (mg/kg)[j]	NEL[k] (mg/kg) [l]
Antimony	64	2.9	--	--	3 M	--	--
Arsenic	150	19	5.9	17	17 I	93	57
Cadmium	12	97.5	0.596	3	3 I	6.7	5.1
Chromium total	280	110	37.3	90	95 H	270 [m]	260 [m]
Copper	840	340	35.7	197	86 I	390	390
Iron (%)	--	--	--	--	4% I	--	--
Lead	720	240	35	91	127 H	530	450
Manganese	1800	1,400	--	--	1,100 I	--	--
Mercury	2.7	0.16	0.174	486	0.56 M	.59	.41
Nickel	--	39	18	35	43 H	--	--
Silver	4.5	3.9	--	--	4 H	6.1	6.1
Zinc	3200	500	123	315	520 M	960	410

Notes:

a Apparent Effects Threshold (AET) is defined as the concentration of a given chemical above which a statistically significant ($p<0.05$) biological effect (“hit) (i.e. mortality) is always expected to occur. Biological effects may be observed in sediments below an AET for a given chemical, and this effect may be caused by other chemicals that occur with the considered chemical. The AET value demarcates the upper boundary of a chemical concentration that may be tolerated by a given organism.

b Cubbage, James, David Batts, Scott Breidenback. 1997. “Creation and Analysis of Freshwater Sediment Quality Values in Washington State”. July. http://www.ecy.wa.gov/pubs/97323a.pdf

c The Probable Apparent Effects Threshold (PAET) is defined as the 95th percentile of values with no significant biological effects and concentrations greater than the lowest “hit” level (see AET). It is designed as an alternative value to the AET to reduce the effects of random error.

d The Threshold Effects Level (TEL) is calculated as the geometric mean of the 15th percentile concentration of the toxic effects data set and the median of the no-effect data set. As such it represents the concentration below which adverse effects are expected to occur only rarely. Freshwater TELs are based on benthic community metrics and toxicity texts results

e National Oceanic and Atmospheric Administration Screening Quick Reference Tables (NOAA SQUIRTs 2004. “Screening Quick Reference Table for Inorganics in Solids.” February. http://response.restoration.noaa.gov/book_shelf/122_squirt_cards.pdf

f The Probable Effects Level (PEL) is calculated as the geometric mean of the 50th percentile of impacted, toxic samples and the 85th percentile of the non-impacted samples. It is the level above which adverse effects are frequently expected. Freshwater PELs are based on benthic community metrics and toxicity texts results.

g For freshwater sediments, the Upper Effects Threshold (UET) was derived by the National Oceanic and Atmospheric Administration (NOAA) as the lowest AET from a compilation of endpoints analogous to the marine AET endpoints. The UETs for organic contaminants are generally listed for a sediment containing 1% Total Organic Carbon (TOC).

h Entry is lowest, reliable value among a compilation of AET levels: I – Infaunal community impacts; H – Hyalella azteca bioassay; M – Microtox bioassay.

i The Washington Minor Adverse Effects Level (MAEL) value is the concentration that results in an acute or chronic adverse effect to biological resources relative to reference in no more than one appropriate biological test, result in a significant response relative to reference, and do not result in significant human health risk.

j Risk Assessment Information System database (http://rais.ornl.gov/cgi-bin/eco/ECO_select), accessed October 4, 2007.

k The Washington No Effect Level (NEL) value is the concentration that does not result in acute or chronic adverse effects to biological resources relative to reference and does not result in significant human health risk. Washington lists criteria for organics other than phenol, 2-methyl phenol, 4-methyl phenol, 2,4-dimethyl phenol, benzyl alcohol, and benzoic acid on a total organic carbon basis.

l Assessment Information System database (http://rais.ornl.gov/cgi-bin/eco/ECO_select), accessed October 4, 2007.

m MAEL and NEL values are for Chromium III

-- Indicates no value was reported.

- **Terrestrial Invertebrates** - Comparison of the concentrations of chemicals in soil with toxicity benchmarks for terrestrial invertebrates. Chemical concentrations in soil will be compared with ORNL benchmarks for invertebrates (Efroymson, et al. 1997b) and Eco-SSLs for invertebrates (EPA 2005). Invertebrate benchmarks are provided on **Table 4-2**. HQs will be developed by dividing the concentration in soil by the invertebrate benchmark. The Eco-SSL plant benchmark will be preferentially selected over the ORNL benchmark if benchmarks are available for both. Potential risk to terrestrial invertebrates will be indicated where HQs in site soil exceed 1.
- **Survival, growth, and reproduction of birds and mammals typical to the area** - Comparison of the concentrations of chemicals in sediment and soil with Eco-SSLs for birds and mammals (EPA 2000b, 2005a-i; 2006a,b, 2007d,e,f). Eco-SSLs for birds and mammals are provided on **Table 4-2**. HQs will be developed by dividing the concentration in sediment and soil by the Eco-SSL. Potential risk to birds and mammals will be indicated where HQs exceed 1.

For COPECs that exceed screening benchmarks for one or more receptors, a primary literature search will identify toxicological effects of COPECs to receptors. Those potential adverse effects will be discussed in the SLERA text.

Results of the SLERA

Based on the SLERA, decisions can be made to on which COPECs and pathways are to be further evaluated in the BERA and which can be eliminated from further consideration.

Following the SLERA, decisions will be made in consultation with DEQ based on the determination of potential ecological risks. Thus, two possible decisions can be reached following the SLERA:

- There is sufficient information to conclude that ecological risks are low or non-existent. Under these conditions, further ERA or remediation for ecological protection is unwarranted, and the Facility may be closed out for ecological concerns.
- The Facility fails the SLERA on the basis that complete pathways and unacceptable risks are indicated for at least one COPEC. Under these conditions, the decision is made to either initiate interim cleanup or proceed to a BERA.

Table 4-4
Selected Surface Water Screening Levels For Ecological Receptors

	EPA Ambient Water Quality Criteria [1]		Montana Water Quality Standards [2]	
Chemical	**CMC acute (freshwater) (ppb)**	**CCC chronic (freshwater) (ppb)**	**CMC acute (freshwater) (ppb)**	**CCC chronic (freshwater) (ppb)**
Aluminum (dissolved, pH 6.5 to 9.0 only)	750 [a]	87 [a]	750 [a]	87 [a]
Antimony	88 [b]	30 [b]	--	--
Arsenic	340	150	340	150
Barium	110	4	--	--
Beryllium	130 [c]	5.3 [c]	--	--
Cadmium[d]	2.1	0.27	2.1	0.27
Chromium III[d]	1803	86	1803	86
Chromium VI	16	11	16	11
Copper[d]	14	9.3	14	9.3
Iron	--	1000	--	1000
Lead[d]	82	3	82	3
Manganese	2,300	120	--	--
Mercury	1.4	0.77	1.7	0.77
Nickel[d]	469	52	469	52
Selenium	13-186 [f]	5 [f]	20	5
Silver[de]	2.0	--	4.1	--
Thallium	1400 [c]	40 [c]	--	--
Tin as TBT	0.46	0.072	--	--
Zinc[d]	120	120	120	120

Notes:

The values shown for CMC and CCC assume a hardness of 100 mg/L $CaCO_3$.

Criteria are generally expressed as dissolved (passing through a 0.45 mm filter) and calculated from total recoverable by applying a conversion factor, except as noted.

a For pH 6.5 to 9.0 and expressed as total recoverable, there are three major reasons why the use of water-effect ratios might be appropriate. (1) the value of 87 µg/L is based on a toxicity test with the striped bass in water with pH=6.5- 6.6 and hardness <10 mg/L. Data in ``Aluminum Water-Effect Ratio for the 3M Plant Effluent Discharge, Middleway, West Virginia'' (May 1994) indicate aluminum is substantially less toxic at higher pH and hardness, but the effects of pH and hardness are not well quantified at this time. (2) In tests with the brook trout at low pH and hardness, effects increased with increasing concentrations of total aluminum even though the concentration of dissolved aluminum was constant, indicating total recoverable is a more appropriate measurement than dissolved, at least when particulate aluminum is primarily aluminum hydroxide particles. However, in surface waters the total recoverable procedure might measure aluminum associated with clay particles, which might be less toxic than aluminum associated with aluminum hydroxide. (3) EPA is aware of field data indicating many high quality waters in the U.S. contain more than 87 µg aluminum/L, when either total recoverable or dissolved is measured (EPA 1998).

b Proposed.

c Lowest Observable Effect Level (not a criterion).

d Hardness-dependent value with 400 mg/L as maximum calcium carbonate; value entered is for 100 mg/L calcium carbonate. Use equations to determine exact criteria.

e EPA CMC has been halved to be comparable to criteria derived using 1985 Guidelines

-- Indicates no value was reported.

Source:

1 EPA 1998, NOAA SQUIRT 2006.

2 Circular DEQ-7 2006.

4.7 GRAPHICAL SITE-SPECIFIC CONCEPTUAL SITE MODEL

4.7.1 Introduction

A source-pathway conceptual model will be developed and presented in the final RI report to aid identification of potential sources of metals and potential pathways of movement of these metals from source materials into surrounding receptors such as soils, groundwater, surface water, sediments, and other affected environmental media.

The source-migration pathway conceptual model will likely illustrate that the primary sources of contaminants are acidic, metal-laden discharges of contaminated groundwater from adits; contaminants leaching from acidic, metal-laden mine waste rock and tailings, and sulfide-bearing vein deposits underground that are exposed to the atmosphere by either mine workings or fracturing and faulting. These sources likely interact with infiltrating surface water or groundwater. Secondary sources of contaminants include stream sediments that have been redistributed as sediments downstream from primary sources including the failure of the tailings dam (1975) at the Mike Horse Tailings Impoundment. The principal release mechanisms and migration pathways for transport of contaminants within the UBMC Facility are described above in Sections 4.3 and 4.4. The site conceptual model will undoubtedly evolve as more information is gathered and as knowledge of the interaction between contaminants and the environment at the UBMC is gained.

4.7.2 Precipitation and Recharge

The majority of precipitation at the UBMC Facility falls as snow in the late fall, winter and early spring, and as rain in late spring and summer storms. The upper Blackfoot River is characterized by rapidly increasing flow rates and short periods of sustained flow during the snowmelt event. As much as 90 percent of the Blackfoot River's discharge volume occurs between mid-May and early July. The Blackfoot River and its tributaries locally receive base flow that results from groundwater seepage from fractured and faulted bedrock. Discharges of groundwater from adits (Mike Horse, Anaconda, Paymaster and other scattered smaller adits) contribute small but varying amounts of flow to the upper Blackfoot River.

Recharge of aquifers at the UBMC Facility is somewhat limited by its high elevation, small upgradient topographic collection area for recharge, and its physiographic position near the continental divide. Recharge of groundwater in shallow aquifers of unconsolidated sediments comes from direct infiltration of snowmelt, runoff, and from the discharge of groundwater from bedrock, where fractures discharge as springs adjacent to or beneath alluvial material. Shallow groundwater in colluvium discharges directly to shallow alluvial aquifers in the Blackfoot River and its tributaries' valleys. Recharge to bedrock occurs primarily as direct infiltration of snowmelt and runoff, particularly where fractures or faults are exposed at the surface, such as along the Mike Horse and Blackfoot Fault systems. Colluvial and alluvial groundwater also discharges to underlying bedrock through infiltration into fractures. Presumably downstream in the hydrologic system, shallow colluvial-hosted groundwater discharges directly to the upper Blackfoot River.

4.7.3 Source Migration Pathways

Source areas in the headwaters of the upper Blackfoot River contain a number of waste rock dumps and secondary deposits of sediment transported from the breaching of the Mike Horse Tailings Dam and other over-bank flow events. In an oxidizing weathering or shallow groundwater environment, these sulfide minerals weather and release sulfuric acid to the waters, which in turn increase the solubility of the metals. There are also historic underground adits with a perennial discharge of water with demonstrated poor quality including the Mike Horse, Anaconda and Paymaster mine adits, and other adits with discharges have been recently identified in peripheral portions of the UBMC.

Sulfide-bearing vein deposits are also exposed to atmospheric oxygen within mine workings and to oxygenated water along natural faults and fractures. The deposits are enriched in sulfide minerals, principally pyrite, chalcopyrite, sphalerite, galena, marcasite and molybdenite, with varying amounts of base and precious metals (Ag, As, Cd, Cu, Fe, Pb, Mn, Mo, and Zn). When exposed to oxygen in the atmosphere, in either mine workings or in groundwater in bedrock fractures and faults, these sulfide minerals oxidize, releasing sulfate, iron, and acidity, which in turn increases the solubility of other metals. Surface water runoff and groundwater ultimately transport these metals to streams.

Physical erosion of materials occurs where waste rock or contaminated soil is exposed at the surface, such as at mine waste rock dumps in adit areas. Surface runoff carries metal-laden sediments to stream channels, where they are entrained in the bed-load of the creek. The mobility of the metals in the streambed is dependent on the chemistry of the water in the stream.

Metals will dissolve into surface water flowing across metal-laden material exposed at the surface. Metal bearing minerals in surficial materials are generally oxidized by exposure to water and atmospheric oxygen, which releases soluble metal salts that are highly mobile under acidic conditions. In addition, slope-wash from snowmelt or rain exposed to contaminate surface material will dissolve metals and transport them laterally to an adjacent stream or downward into underlying soil and groundwater. This occurs where sulfide ore is present in the shallow subsurface or in underground mine workings.

Groundwater can enter underground mine workings where workings intersect saturated bedrock fractures transmitting groundwater. The addition of atmospheric oxygen within the workings can enhance the dissolution of metals. Mine workings frequently act as conduits for groundwater, allowing water collected underground to discharge directly to surface water. This has historically occurred from the Mike Horse, Anaconda, and Paymaster mines and other recently discovered underground workings occurring on the southern periphery of the district.

Groundwater can transport dissolved contaminants to surface water at seeps and springs or anywhere else where groundwater directly discharges to the creek. Surface water can also transport metals to groundwater as it infiltrates into bedrock.

One of the principal controls of water quality in the upper reaches of Paymaster Creek may be the precipitation of iron and aluminum oxyhydroxide minerals, with co-precipitation and adsorption of metals to these phases to form ferricretes deposits (Furniss 1998). These reactions control the concentration of metals in the stream, maintaining equilibrium between the secondary metal oxyhydroxides with dissolved metals in the overlying water column.

Additional loading of contaminants to surface water, can be attributed to the influx and mixing of groundwater along the upper Blackfoot River, but it is difficult to identify specific areas where groundwater with low pH and high metals content are discharging. If the contaminated groundwater component is significant, even the removal of key primary sources of contaminants at the surface may not improve water quality sufficiently to meet water quality standards further down gradient in the stream.

As water flows down the upper Blackfoot River, less acidic surface and groundwater with more alkalinity enters the river through tributaries and changes the chemistry of the water, raising the pH and diluting metal concentrations. As a result, settling of colloidal metals, co-precipitation of dissolved metals with ferric-hydroxides, or reduction and sorption of metals in marshes and wetlands produce an overall improvement of water quality so that water quality impacts at surface water site downstream are minor relative to those in the upper Blackfoot River drainage.

4.7.4 Exposure Pathways

Exposure pathways to humans and ecological receptors from mine waste sources are primarily related to direct contact or ingestion of contaminants (CSEM; **Figure 4-1**). As the main sources present in the UBMC Facility are located away from permanent residents, consumption of groundwater or surface water is not considered a significant exposure pathway for humans; however, this exposure pathway will be retained for analysis as groundwater resources could be developed and used in the future. The exposure of ecological receptors to surface water or consumption of surface water is considered to be a complete exposure pathway (see Section 4.6).

Exposure pathways to aquatic organisms primarily occurs in-stream. Aquatic exposure results from contact with or consumption of metals-laden sediment and surface water. Plants that might re-colonize waste dumps or other areas of mine waste deposition are exposed to metals contaminants primarily from root uptake. These plants are often weakened or absent due to uptake of metals and low pH of waste materials. Potential receptors of impacted soils, sediments, and water, which are included in the CSEM (**Figure 4-1**) and include humans, aquatic life, plants, birds, fish, and animals.

4.8 POTENTIAL REMEDIAL ACTION OBJECTIVES

Remedial action objectives are site-specific goals developed for the UBMC Facility that are designed to protect human health and the environment. These objectives specify the contaminants of concern; identify release mechanisms, migration routes, receptors and exposure pathways. In addition, the objectives typically identify an acceptable concentration range for each contaminant for the various exposure pathways. Historical data generated for various media are combined with new data as it is generated from implementation of the RI for incorporation into a comprehensive RI Report. Measured concentrations of constituents from the UBMC Facility for various media (including mine wastes, soils, surface water, surface water sediments, groundwater, benthic macroinvertebrates and periphyton, vegetation, and small mammals) will be compared with screening criteria, derived from Montana Tier 1 Risk–Based Screening Levels (DEQ 2007) (if a petroleum waste source is identified), EPA Region 9 preliminary remediation goals (PRGs) and soil screening levels with a dilution attenuation factor of 10 (EPA 2004) per DEQ's Voluntary Cleanup and Redevelopment Act guide (DEQ 2002); Montana water quality standards (Circular DEQ-7) (DEQ 2006); and the previously identified screening criteria used for the SLERA.

The COPCs identified from historical studies of the UBMC Facility include, but are not limited to, aluminum, arsenic, cadmium, copper, lead, iron, manganese and zinc. Other COPCs and resulting pathways and receptors may be identified during the RI process.

Preliminary Remediation Goals will be derived from the site-wide conceptual model used in combination with existing information for the UBMC Facility. Screening values using Montana water quality standards and reporting limits for selected constituents are presented in the SAP (**Appendix A**) and will be included as part of the Preliminary Remedial Action Objectives. Site-specific cleanup or remedial action levels will be established based on the RI, migration pathway evaluation, risk assessments, and analysis of Environmental Requirements, Criteria or Limitations (ERCLs) established later in the RI and Feasibility Study process.

4.8.1 Preliminary List Of Remedial Action Alternatives

The discussion of the Nature and Extent of Contamination (Section 3) was organized by contaminated media that included: mine wastes and soil, surface water, surface water sediments, groundwater, benthic macroinvertebrates, and periphyton. This section briefly looks at preliminary remedial action alternatives or site specific remediation technologies that might be suitable for use at the UBMC Facility in meeting the remedial action objectives. Because 2007 studies are currently underway, this discussion is focused on identifying data gaps and sampling needs that might be necessary to fill during implementation of the RIWP and in order to evaluate the feasibility of possible remedial action alternatives for the UBMC Facility. The remedial action alternatives identified here may change as the result of these ongoing studies.

As will be seen below, remedial action alternatives may be applicable to more than one medium, and some remediation technologies could be used to treat more than one medium at the same time. The number and type of remedial action alternatives may change as additional data become available. The actual detailed development and screening of remedial action alternatives and available technologies will take place during the Feasibility Study.

4.8.2 Remediation Alternatives for Mine Waste, Soil and Transported Sediment

Mine waste (and tailings), contaminated soils, and transported and redeposited contaminated soils / sediment media each lend themselves to common remediation alternatives at the UBMC Facility. The remediation alternatives generally include: treatment in-place and excavation and disposal.

Some options or alternatives for soil remediation identified for the UBMC Facility include:

- Consolidation of wastes, grading and compaction;
- Erosion protection, run-on / run-off controls:
- In-situ soil amendment / fixation or other similar treatment and vegetative cover:
- Water balance soil / engineered synthetic / or vegetative cover;
- Soil excavation:
  - On-site treatment and disposal,
  - Off-site disposal,
- Combination of the above technologies; and
- No action.

4.8.3 Remediation Alternatives for Contaminated Surface Water

Treatment of surface water contamination typically involves removal of a source that is causing the contamination; however, natural attenuation, or treatment of contaminated surface water are other options.

Potential surface water remediation options or alternatives identified for the UBMC Facility include:

- Source contamination removal;
- Treatment:
  - Active water treatment,
  - Passive wetland treatment,
  - Reactive barriers;
- Remediation by monitoring natural attenuation;
- Combination of the above technologies; and
- No Action.

4.8.4 Remediation Alternatives for Contaminated Groundwater

Treatment of groundwater contamination may involve removal of a source that is contaminating groundwater, natural attenuation, treatment of contaminated groundwater; containment of contaminated groundwater; and restriction, reduction or elimination of contaminated groundwater flow.

Potential groundwater remediation options or alternatives identified for the UBMC Facility include:

- Source contamination removal;
- In-situ groundwater treatment;
- Pump-and-treat;
- Active water treatment;
- Passive wetland treatment;
- Remediation by monitoring natural attenuation;
- Restriction, reduction or elimination of flow;
- Fracture / fault grouting (underground in mines or surface grouting);
- Adit / portal plugs;
- Near-surface reactive barriers;
- Combination of the above technologies; and
- No action.

4.9 DATA NEEDED FOR REMEDIAL ALTERNATIVES EVALUATION

Based on the preliminary evaluation of contaminated media and likely remedial alternatives, the following information is considered necessary to conduct the evaluation of remedial alternatives for the UBMC Facility:

- Final list of contaminants of concern;
- Clean-up goals for all affected media;
- Location, area (footprint), and volume of mine waste, soil, and transported sediment that contains concentrations of contaminants of concern above cleanup goals;
- Metal values, ABA data and metal mobility data of mine waste, soil, and transported sediment that contains concentrations of contaminants of concern above cleanup goals;
- Source data for surface water contamination; location, metal concentrations above clean-up goals for surface water, metal loading data, and flow volumes;

- Clearly defined groundwater flow paths for source control and remediation of groundwater containing contaminants of concern above the clean-up goals;
- Groundwater direction and rates of flow in alluvial, bedrock and perched aquifers; aerial and vertical extent of contamination in groundwater;
- Physical parameters for the saturated and unsaturated zone throughout the Facility; and
- Understanding of the interconnection between groundwater and surface water.

Figure 4-1 Preliminary Site Conceptual Exposure Model

5.0 DETAILS OF THE 2007/2008 RIWP

5.1 WORK PLAN RATIONALE

The overall objective of the RI is to characterize the nature and extent of contamination at the UBMC Facility. In order to meet this objective, a review of the fate and transport of contaminants is undertaken in this RIWP to develop a preliminary site-wide conceptual model for the UBMC. The fate and transport discussion identifies potential contaminants of concern, source areas, release mechanisms, migration pathways, and attenuation mechanisms. Identified data gaps will be used to select appropriate sample types and methods to further characterize sources and evaluate migration pathways. This information is then used in the RI Report to quantify a human and ecological risk- based exposure analysis and support development and evaluation of remedial alternatives. The general scope of the RI approach is presented here; detailed development of the RI sampling plan, including rationale, is presented in the SAP (**Appendix A**).

The optimized sample design will be developed giving consideration to the following purposes and general investigation objectives for the UBMC RI.

- Investigate the chemical nature and extent (area of impact and volume of material) of known and suspected sources, including mine waste rock, tailings, contaminated transported and redeposited sediments, reclaimed waste rock removal areas, modern stream sediments and other contaminated soils.
- Investigate the water chemistry, chemical loading and flow rates from known adit discharges to surface or groundwater that have not been previously calculated.
- Investigate the nature, extent, and migration of contamination across and through the UBMC Facility by surface and groundwater. This investigation will focus on delineating the lateral and vertical extent of contamination in groundwater. In addition, this investigation will describe alluvial and bedrock aquifer characteristics; contamination in surface water (predominantly metals), acid loading to surface water from various sources, and recent stream sediment; and the degree of interaction and connectivity of surface water and groundwater aquifers. Additional surface and groundwater quality and quantity (flow) data will be collected. Finally, an appropriate number of samples will be collected to establish background COPCs in soils, surface and groundwater.
- Characterize the risks at the Facility. This investigation will gather data needed to evaluate risks to human health and the environment. The investigation will characterize (from an RI standpoint) contaminated media and identify likely exposure pathways and receptors, and collect sufficient data to allow for development of cleanup levels, including leaching to groundwater).
- Gather data needed to evaluate likely remedial actions. The investigation will gather data to support evaluating likely remedial options. Some likely remedial alternatives

can be identified at this time, although options will not be thoroughly identified and evaluated until the Feasibility Study.

5.2 DATA QUALITY OBJECTIVES

Data quality objectives (DQO) are used to identify the quantity and quality of data collected in the field to support the objectives of the RI at the UBMC Facility. They are also used to establish performance criteria for implementation of the systematic planning process and measurement system that will be employed in generating the data (EPA 1998). This RIWP, SAP (**Appendix A**), and Quality Assurance Program Plan (QAPP; **Appendix A**) assist in ensuring that data collected for the characterization of environmental processes and conditions at the UBMC Facility are of the appropriate type and quality for their intended use, and that environmental technologies are designed, constructed, and operated according to established expectations. Systematic planning is a key project-level component.

Tetra Tech and the DEQ Remediation Division staff have discussed the purpose and objectives of this investigation, as well as the sampling methodology presented in this RIWP and in the SAP (**Appendix A**). It is anticipated that DEQ will be instrumental in the process of developing and approving DQOs for the UBMC. Project objectives are organized into four logical investigation components for this RIWP and SAP (**Appendix A**). These components include:

- Investigation — Source Areas
- Investigation — Nature, Extent, and Migration of Potential Contaminants of Concern
- Investigation — Human Health and Ecological Streamlined Risk Characterization
- Investigation — Remedial Alternatives

These components together form an integrated site-wide investigation plan and will be supplemented by a variety of mine waste, contaminated soil, surface water, streambed sediment, groundwater, and benthic macroinvertebrate samples collected based on the stated objectives. The detailed development of the DQOs is presented in the SAP (**Appendix A**).

5.3 REMEDIAL INVESTIGATION SPECIFIC WORK PLAN TASKS

The major objective of the RIWP is to insure that defensible and appropriate physical, chemical, geological, hydrogeological and risk assessment data are collected at the UBMC Facility. Specific objectives of the RIWP include (1) evaluating previously collected site data for validity and applicability to the RI objectives, (2) collecting data necessary to assess the human health and ecological risks at the UBMC Facility and in adjacent or downstream affected areas, (3) identifying and characterizing contaminant sources, (4) defining the nature and extent of the contamination at the UBMC Facility, (5) evaluating the fate and transport of potential contaminants of concern, and (6) providing data sufficient to support the development and evaluation of remedial alternatives in the Feasibility Study. The general scope of the RI tasks is presented here; detailed development and presentation of the specific sampling tasks are presented in the SAP (**Appendix A**).

The principal RI tasks include:

- Project planning;
- Design an RI that builds on existing data;
- Design an RI that identifies and fills data gaps;
- Collecting data necessary to conduct the baseline risk analyses (both human health and ecological);
- Collecting data necessary to support development and evaluation of remedial alternatives; and
- RI report preparation.

All of these tasks will be conducted in accordance with CECRA as well as EPA, and DEQ guidance, as appropriate. DEQ's Remediation Division is currently planning the project and will conduct community relations. Specific site characterization activities are developed in a general manner in this RIWP and more specifically in the SAP (**Appendix A**). The risk analysis approach and methodology will be further developed through meetings with DEQ's Remediation Division.

The primary data gathering tasks at the UBMC Facility that are developed in detail in the SAP (**Appendix A**) are described below.

5.3.1 Investigation — Source Areas

- Further investigate the nature and extent of suspected sources in the UBMC by filling identified data gaps for mine waste rock and tailing, and transported sediment;
- Further investigate the nature and extent of surface and groundwater contamination at the UBMC Facility including:
    - High flow annual surface water sampling event, Seasonal surface water sampling;
    - Synoptic surface water sampling events prior to and following major district-wide reclamation activities;
    - Adit discharge sampling for Paymaster (historical seepage, describe) and newly discovered (2007) adits with seepage; and
    - Annual high flow groundwater / Monitor well sampling.
- Further delineate the lateral and vertical extent of transported sediment

5.3.2 Investigation — Nature, Extent, and Migration of Contaminants of Potential Concern

- Investigate the nature, extent, and migration of contamination in soil, surface and groundwater and sediment;
- Establish background concentrations of constituents in soil, surface and groundwater and sediment;
- Further characterize aquifer characteristics;
- Further characterize contamination in transported and redeposited contaminated sediment, including mine tailing waste, dispersed tailing, over-bank deposits, and modern stream sediments;
- Further characterize connectivity and interaction between groundwater and surface water; and
- Evaluate effectiveness of past removal actions.

5.3.3 Investigation — Risk Characterization

- Gather necessary data to quantify the human health and environmental risks at the UBMC Facility;
- Characterize contaminated media from a risk analysis standpoint; and
- Identify likely exposure pathways and receptors.

5.3.4 Investigation — Remedial Alternatives

Gather data needed to support evaluation of likely remedial alternatives.

In addition to ongoing annual high flow surface and groundwater sampling by Tetra Tech, there are other conceptual reasons for additional sampling in spring 2008 at the UBMC Facility that include:

- Address the sampling for data gaps;
- Provide infill data (data density sampling);
- Collect data to confirm earlier interpretations;
- Identify and collect data in areas of incomplete understanding of system;
- Collect data to address data gaps related to additional data types or media sampling; and
- Identify data limitations and required future work.

Finally there are a list of other specific tasks that have been identified and need to be completed during the RI process (prior to the preparation of the RI Report). These tasks include:

- Understanding the reasons for and evaluating past, current and proposed reclamation actions by ASARCO/ARCO (for example: Section 75-10-721, MCA, require the evaluation of seven remedy selection criteria; Mike Horse and Carbonate repositories need confirmation sampling, water quality data suggest ongoing impacts at Mike Horse removal sites);
    - Review *Mike Horse Mine Cleanup,*
    - Review *Carbonate Mine Cleanup,*
    - Review *Anaconda Mine Cleanup,*
    - Review *Edith Mine Cleanup,*
    - Review *Paymaster & No. 3 Tunnel Mine Cleanup,*
    - Review *Consolation Mine Cleanup, and*
    - Review *Capital Mine Cleanup;*
- Revegetation performance monitoring;
- Completion of tasks in RI Report not requiring additional field work for revegetation performance monitoring; and
- Description of other information and evaluations necessary for RI.

6.0 PROJECT MANAGEMENT

The DEQ liaison for Task Order No. 9 is David Bowers (406-841-5063). The project liaison / manager for Contractor is Allan Kirk (406-582-8780). DEQ's alternate liaison is Denise Martin (406-841-5060) and Contractor's alternate liaison is Natalie Morrow (406-543-3045). Verbal communications between DEQ and Tetra Tech that affect the scope, schedule or budget for services shall be confirmed in writing and submitted to DEQ by the Contractor for DEQ approval.

6.1 PROJECT ORGANIZATION

6.1.1 Key Personnel

DEQ has identified the following employees of the Contractor as Key Personnel for purposes of performing work under this Task Order:

- Allan Kirk, Project Manager; (406) 582-8780
- Natalie Morrow, Assistant Project Manager; (406) 543-3045
- Rich Dombrouski, Senior Engineer/Scientist; (406) 543-3045
- Cindi Rose, Senior Ecological Risk Assessor; (415) 543-4880
- Shirley Fu, Senior Human Health Risk Assessor; (303) 312-8800

No addition or substitution of Key Personnel shall be allowed without the prior written permission of DEQ.

6.2 PROJECT SCHEDULE

A copy of the abbreviated schedule for the RI at the UBMC Facility is presented as RI fieldwork began on October 3, 2007 and continued through October 26, 2007 for the 2007 calendar year. The Draft RIWP report was submitted to DEQ by October 31, 2007 and the Draft Final RIWP was submitted on December 3, 2007. The Final RIWP must be submitted to DEQ no later than December 31, 2007.

Task No.	Task	Start Date	End Date	Calendar Days Duration
4	Draft RIWP	Oct. 1, 2007	Oct. 31, 2007	
4	DEQ Comment Period on Draft Work Plan	Oct. 31, 2007	Nov. 15, 2007	15
4	Incorporate comments into Draft Final Work Plan	Nov. 15, 2007	Dec. 3, 2007	18
4	DEQ Comment Period on Draft Final Work Plan that includes comments for the fall 2007 Season-Specific Investigation report (Completion of Task 3)	Dec. 3, 2007	Dec. 11, 2007	9
4	Incorporate comments into Final Work Plan and submit to DEQ	Dec. 11, 2007	Dec. 31, 2007	20
5	Determine data gaps	Nov. 30, 2007	Feb. 15, 2008	77
5	Meet with DEQ	Feb. 15, 2008	Feb. 29, 2008	14
5	Technical Memorandum summarizing meeting	Feb. 29, 2008	March 7, 2008	7
6	Conduct field sampling	March 7, 2008	June 19, 2008	105 (WD)
6	Receive data	May 15, 2008	June 25, 2008	42
6	Analytical data validation	May 15, 2008	July 31, 2008	68
7	Evaluate data and incorporate results into Draft RI Report	June 25, 2008	July 31, 2008	37
7	DEQ Comment on Draft RI Report	July 31, 2008	Aug. 29, 2008	30
7	Incorporate comments into Final Draft RI Report	Aug. 29, 2008	Oct. 13, 2008	46
7	Public Comment Period	Oct. 15, 2008	Nov. 13, 2008	30
7	DEQ Comments on Final Draft RI Report (including public comments)	Nov. 13, 2008	Dec. 12, 2008	30
7	Prepare Final RI Report	Dec. 22, 2008	Jan. 30, 2009	12

Table 6-1
Schedule

RI = Remedial investigation
DEQ = Montana Department of Environmental Quality
WD = Weather Dependent

6.3 REMEDIAL INVESTIGATION REPORTING REQUIREMENTS

Tetra Tech is required under the terms of the contract to provide the following deliverables to DEQ:

- Draft RIWP
- Draft RIWP that incorporates DEQ comment responses
- Draft Final RIWP that incorporates DEQ comment responses for the fall 2007 Season-Specific Investigation report (completion of Task 3)
- Final RIWP
- Draft RI Report

- Draft Final RI Report that incorporates DEQ comment responses
- Final RI Report

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APPENDIX A
DRAFT 2008 SAMPLING AND ANALYSIS PLAN

APPENDIX B
TABLES

Table B- 1
2007 Mine Inventory Data

Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
BR-01	001- Belle of the Hill	BR-01-001 to 002	Blackfoot River	Belle of the Hill	Belle of the hill	Adit		47.03769313	-112.3658488	5,312	6300 sf	700	X	200	Intermittent spring (150 square feet) at toe of slope were adit was likely located. Large floodplain bench which is possible tailings.	X	X
BR-02	002- Belle of the Hill	BR-02-003	Blackfoot River	Belle of the Hill	--	Exploratory dig out		47.03810234	-112.3655688	5,371	11 cy	33	--	--	No tailings evident.		
JM-01	020- Jumbo Mine	JM-01-021 to 025	Paymaster Gulch	Jumbo	Jumbo mine	Adit		47.03679384	-112.3838562	5,629	56 cy	542	--	--	Adit trench and waste pile onsite.	X	
JM-02	021- Jumbo Mine	JM-02-024	Paymaster Gulch	Jumbo	Jumbo mine	Exploratory drill pad		47.03663969	-112.3824271	5,468	3200 sf	--	--	--	Appears tailings from Jumbo adit have been incorporated into fill material for drill pad (quantity unknown).	X	
PM-01	440- Paymaster	PM-01-046 to 047	Paymaster Gulch	Black Diamond	Paymaster	Exploratory pit		47.03748149	-112.3869125	5,364	50 cy	11	--	--	No tailings evident.		
PM-02	442- Paymaster Tunnel 3	PM-02-048 to 049	Paymaster Gulch	Paymaster	Paymaster Tunnel 3	Tunnel		47.03852545	-112.3855776	5,282	--	--	--	--	Revegetation in good condition.		
PM-03	443- Paymaster	PM-03-050	Paymaster Gulch	Paymaster	--	Trench		47.03807174	-112.3864707	5,348	56 cy	--	--	--	Four trenches east of Tunnel No. 3 200 feet.		
PM-04	444- Paymaster	PM-04-051 to 052	Paymaster Gulch	Paymaster	Diamond bit drill hole	Exploratory pit		47.03783378	-112.3871928	5,397	142 cy	106	--	--	Exploratory pit with possible tailings	X	
PM-05	445- Paymaster	PM-05-053	Paymaster Gulch	--	--	Trench		47.0375436	-112.3917602	5,446	27 cy	--	--	--	Two trenches located beyond Paymaster claim boundary.		
PM-06	446- Paymaster	PM-06-054 to 056	Paymaster Gulch	Black Diamond	--	Trench		47.03684857	-112.3872329	5,499	285 cy	423	--	--	Two trenches located digout. Possible tailings.		
PM-07	447- Paymaster	PM-07-057	Paymaster Gulch	Black Diamond	--	Exploratory dig out		47.0373302	-112.387098	5,479	3 cy	--	--	--	Small dig out. No tailings evident.		
PM-08	448- Paymaster Tunnel No. 2	PM-08-059	Paymaster Gulch	Black Diamond	Paymaster Tunnel 2	Tunnel		47.03637407	-112.3859447	5,417	--	--	--	--	Revegetation in good condition.		
PM-09	448- Paymaster Tunnel No. 2	PM-09-058	Paymaster Gulch	Black Diamond	Paymaster Tunnel 2	Trench		47.03637407	-112.3859447	5,417	93 cy	--	--	--	Trench just upslope of revegetation. No tailings evident.		

Table B- 1
2007 Mine Inventory Data

Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
PM-10	448-Paymaster Tunnel No. 2	--	Paymaster Gulch	Black Diamond	Paymaster Tunnel 2	Trench		47.03637407	-112.3859447	5,417	16 cy	--	--	--	No tailings evident.		
PM-11	449-Paymaster	PM-11-060 to 061	Paymaster Gulch	--	--	Trench		47.0349955	-112.3873019	5,502	67 cy	33	--	--	300 feet southeast of Paymaster Tunnel No. 2 above access road. Copper salts observed on surface rock.	X	
PM-12	450-Paymaster	PM-12-062 to065	Paymaster Gulch	--	--	Adit	X	47.03501662	-112.3869881	5,482	113 cy	1,288	--	--	Collapsed adit entrance and large waste rock pile within 5 feet of the creek.	X	X
PM-13	451-Paymaster	PM-13-066 to 067	Paymaster Gulch	Black Diamond	DD hole	Ground disturbance		47.03680926	-112.3857658	5,217	336 cy	--	--	--	Possible DD hole along powerline route. Fill material brought in to widen the road. Possible tailings material.	X	
PM-14	452-Paymaster Tunnel	PM-14-068	Paymaster Gulch	Paymaster	Paymaster	Tunnel		47.03773152	-112.3855611	5,295	--	--	--	--	Seep adjacent to adit reclamation sampled in 2007. Revegetation in good condition.		
PM-15	001-Paymaster	PM-15-001 to 002	Paymaster Gulch	--	--	Trench		47.03409637	-112.3873469	5,434	--	6	--	--	Digout 10 feet upslope (1.8 cy). No tailings evident.		
PM-16	002-Paymaster	PM-16-003	Paymaster Gulch	--	--	Exploratory dig out		47.03185455	-112.3874718	5,601	1 cy	1	--	--	No tailings evident.		
PM-17	003-Paymaster	PM-17-004	Paymaster Gulch	--	--	Exploratory dig out		47.03138265	-112.3870724	5,566	1 cy	1	--	--	No tailings evident.		
PM-18	004-Paymaster	PM-18-005	Paymaster Gulch	--	--	Exploratory dig out		47.03090991	-112.386823	5,595	16 cy	--	--	--	No defined waste rock pile or tailings evident.		
PM-19	006-Paymaster	PM-19-006 to 007	Paymaster Gulch	--	--	Exploratory dig out		47.02878443	-112.3863732	5,588	5 cy	6	--	--	No tailings evident.		
PM-20	008-Paymaster	--	Paymaster Gulch	--	--	Stream		47.02819342	-112.3850929	5,598	--	--	--	--	stream becomes intermittent above this point. No iron staining. White milky standing water.		
PM-21	009-Paymaster	--	Paymaster Gulch	--	--	Cabins		47.02819895	-112.3850559	5,530	--	--	--	--			

Table B- 1
2007 Mine Inventory Data

Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
PM-22	010-Paymaster	PM-22-009 to 011	Paymaster Gulch	--	--	Ground disturbance		47.02747358	-112.3853186	5,532	400 sf	--	--	--	Large V-shape channel running 100 feet to main stream channel. Uncertain if this is natural or man-made. White staining on rocks in channel bottom. Head of channel sloughing into channel.	X	X
PM-23	011-Paymaster	--	Paymaster Gulch	--	--	Exploratory dig out		47.02747358	-112.3853186	5,532	25 sf	--	--	--	Three small dig outs (10 sf each). No tailings evident.		
PM-24	012-Paymaster	--	Paymaster Gulch	--	--	Road		47.02747358	-112.3853186	5,532	--	--	--	--	End of access road.		
PM-25	014-Paymaster	PM-25-012	Paymaster Gulch	--	--	Exploratory drill pad		47.02747358	-112.3853186	5,532	875 sf	--	--	--	Fill from road cut pushed into intermittent channel. No waste rock piles or tailings evident. Bucket, cable and wooden pole onsite. Wildlife wallow at upstream end of pad.		
PM-26	015-Paymaster	PM-26-013	Paymaster Gulch	--	--	Waste rock		47.02486865	-112.3816488	5,532	--	2,689	--	--	Large tailings pile with access road at its toe which bisects the intermittent Paymaster creek channel.	X	
PM-27	016-Paymaster	PM-27-0014 to 0016	Paymaster Gulch	--	--	Adit		47.02666615	-112.374966	5,605	1950 sf	--	--	--	Small moss mat is located were the old adit entrance was located. No surface water was visible.		
PM-28	017-Paymaster	PM-28-017 to 019	Paymaster Gulch	--	--	Adit		47.02264359	-112.3767602	6,536	18 cy	167	--	--	Trench remaining from an old adit. Three lupine plants observed growing along the edge of the tailings pile.	X	
PM-29	018-Paymaster	PM-29-020	Paymaster Gulch	--	--	Exploratory dig out		47.02338472	-112.379635	6,058	1 cy	--	--	--	No tailings evident.		
PM-30	019-Paymaster	--	Paymaster Gulch	--	--	Exploratory dig out		47.02769486	-112.3848262	5,640	38 cy	--	--	--	Dig out on edge of access road. No waste rock or tailings evident.		

Table B- 1
2007 Mine Inventory Data

Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
SG-01	003- Stevens Gulch	SG-01-005	Stevens Gulch	--	--	Exploratory drill pad		47.03760412	-112.3742944	5,381	3825 sf	29	--	--	Open well casing (8 inches). Possible safety hazard.		
SG-02	004- Stevens Gulch	SG-02-006	Stevens Gulch	--	--	Exploratory drill pad		47.03695402	-112.3787734	5,499	4000 sf	83	--	--	Claim corner marker. Drilling debris downslope.		
SG-03	005- Stevens Gulch	SG-03-007	Stevens Gulch	--	--	Exploratory drill pad		47.03572699	-112.3782784	5,692	3850 sf	33	--	--	Two drilling sites within 100 feet of each other. Drilling debris downslope.		
SG-04	006- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03638237	-112.3771576	5,656	4250 sf	15	--	--	Cement cap on toe of slope. Drilling debris downslope.		
SG-05	007- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03554778	-112.3762386	5,673	3200 sf	41	--	--	Drilling debris downslope.		
SG-06	008- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad/ logging		47.03245008	-112.3769536	5,741	3825 sf	--	--	--	Difficult to determine nature of disturbance as the area is on the edge of a logging unit.		
SG-07	009- Stevens Gulch	SG-07-008	Stevens Gulch	--	--	Exploratory drill pad		47.03385682	-112.376701	5,761	2600 sf	78	--	--	Possibly mine site. Cut timber and other. Concentrated tailings area.	X	
SG-08	010- Stevens Gulch	SG-08-009	Stevens Gulch	--	--	Exploratory drill pad		47.03495284	-112.3775094	5,745	3500 sf	1	--	--	Waste rock pit with possible tailings. Drilling debris downslope.	X	
SG-09	011- Stevens Gulch	SG-9-010	Stevens Gulch	--	--	Exploratory drill pad		47.0335865	-112.3775877	5,866	3400 sf	--	--	--	No tailings evident.		
SG-10	012- Stevens Gulch	--	Stevens Gulch	--	--	Mine workings		47.02162301	-112.3700612	6,778	2250 sf	--	--	--	No tailings evident.		
SG-11	013- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory dig out		47.02119662	-112.3738532	6,719	500 sf	--	--	--	Five dig outs all approximately 10 feet by 10 feet within 50 square foot area. No tailings evident.		
SG-12	014- Stevens Gulch	SG-12-011	Stevens Gulch	--	--	Exploratory dig out		47.0228176	-112.3710885	6,440	900 sf	11	--	--	Difficult to determine nature of disturbance but there are two cut slopes adjacent to each other with small waste rock piles and an original claim marker.		

Table B- 1
2007 Mine Inventory Data

Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
SG-13	015- Stevens Gulch	SG-13-012	Stevens Gulch	Black Ore	--	Waste rock		47.02409492	-112.3671707	6,375	16500 sf	5,440	--	--	Large waste rock pile up to 20 feet deep.	X	
SG-14	015- Stevens Gulch	SG-14-013	Stevens Gulch	Black Ore	--	Trench		47.02409492	-112.3671707	6,375	3000 sf	111	--	--	Trench associated with SG-14.	X	
SG-15	016- Stevens Gulch	SG-15-014	Stevens Gulch	Capital	--	Trench		47.02506579	-112.3669593	6,345	22 cy	6	--	--	Possible tailings in waste rock.	X	
SG-16	017- Stevens Gulch	SG-16-015	Stevens Gulch	Capital	Capital Tunnel 18	Exploratory pit		47.02536964	-112.3677736	6,306	7000 sf	333	--	--	Trench above possible adit location with large waste rock piles associated with both sites.	X	
SG-17	018- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.02604287	-112.3769694	6,414	2625 sf	--	--	--	Drilling debris downslope.		
SG-18	019- Stevens Gulch	SG-18-016	Stevens Gulch	B	--	Adit		47.02697318	-112.3772232	6,260	--	6	--	--	Possible adit location with tailings in waste rock pile.	X	
SG-19	020- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.02777617	-112.3782734	6,224	3000 sf	--	--	--	Drilling debris downslope.		
SG-20	021- Stevens Gulch	SG-20-017	Stevens Gulch	--	--	Waste rock		47.02822326	-112.3791317	6,155	--	15	--	--	Drilling debris downslope.		
SG-21	022- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.0278242	-112.3792606	6,276	3600 sf	53	--	--	Access road cuts waste rock piles. Possible tailings.	X	
SG-22	023- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory site		47.02692063	-112.379191	6,247	5000 sf	--	--	--	Small scale exploratory disturbance. No tailings evident.		
SG-23	024- Stevens Gulch	SG-23-018 to 019	Stevens Gulch	--	--	Exploratory drill pad		47.02738926	-112.3793646	6,257	--	8	--	--	Roadbed impacted by tailings deposits.	X	
SG-24	025- Stevens Gulch	SG-24-020	Stevens Gulch	--	--	Trench		47.02885701	-112.3795323	6,175	2400 sf	293	--	--	Two trenches that intersect at waste rock pile. No tailings evident.		
SG-25	026- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory pit		47.02918533	-112.3798434	6,155	20 cy	--	--	--	Test pit.No tailings evident.		
SG-26	027- Stevens Gulch	SG-26-021	Stevens Gulch	--	--	Exploratory drill pad		47.02948138	-112.3801314	6,158	--	4	--	--	Drilling debris downslope.		
SG-27	028- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory dig out		47.03188422	-112.3797638	6,106	9 cy	--	--	--	Old point-of-discovery dig out. No tailings evident.		
SG-28	029- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03122322	-112.3795998	6,053	2800 sf	--	--	--	Drilling debris downslope.		
SG-29	030- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03346589	-112.3801292	6,014	1800 sf	--	--	--	Exploratory pit adjacent (9 cubic yards). No tailings evident.		

Table B- 1
2007 Mine Inventory Data

Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location: Latitude	Site Location: Longitude	Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling: Soil	2008 Recommended Sampling: Surface Water
SG-30	031- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03695117	-112.3760586	5,978	3200 sf	--	--	--	Drilling debris downslope.		
SG-31	032- Stevens Gulch	SG-31-022	Stevens Gulch	--	--	Water quality		47.03604718	-112.3724879	5,515	300 sf	--	--	--	Deposit of iron rich soil impacting water quality. Likely native material.	X	X
SG-32	033- Stevens Gulch	--	Stevens Gulch	--	--	Waste rock		47.03597308	-112.3729155	5,384	--	1	--	--	Tailings deposited in dig out pit. Source of the tailings is unknown.	X	
SG-33	034- Stevens Gulch	SG-33-023	Stevens Gulch	--	--	Waste rock		47.03615346	-112.3721647	5,417	--	104	--	--	Possible tailings in waste rock.	X	
SG-34	035- Stevens Gulch	SG-34-024	Stevens Gulch	--	--	Waste rock		47.03645479	-112.3725129	5,302	--	65	--	--	Possible tailings in waste rock.	X	
SG-35	036- Stevens Gulch	SG-35-025	Stevens Gulch	--	--	Trench		47.0365397	-112.3724723	5,384	108 cy	119	--	--	Standing water in trench adjacent to creek. No staining evident.	X	
SG-36	037- Stevens Gulch	SG-36-026	Stevens Gulch	--	--	Trench		47.03641824	-112.3721345	5,325	47 cy	67	--	--	Standing water in trench adjacent to creek. No staining evident.	X	
SG-37	038- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03506432	-112.3726714	5,351	--	--	--	--	Debris entering creek from pad located 150 feet upslope.	X	
SG-38	039- Stevens Gulch	SG-38-027 to 029	Stevens Gulch	--	--	Waste rock		47.03747202	-112.3719595	5,289	--	97	--	--	White staining of material in creek bed. Possible old roadbed.	X	
SG-39	040- Stevens Gulch	--	Stevens Gulch	--	--	Waste rock		47.03785876	-112.3708754	5,299	--	19	--	--	Two waste rock piles along Paymaster road.	X	
SG-40	453- Capitol	SG-40-069 to 070	Stevens Gulch	Capital	Capital Tunnel 8	Tunnel		47.02573467	-112.371028	5,886	--	--	--	--	Revegetation in good condition.		
SG-41	454- Capital	SG-41-071 to 072	Stevens Gulch	Capital	--	Trench		47.02573568	-112.3715472	5,928	3667 cy	2,444	--	--	Exploratory trench with possible tailings.	X	
SG-42	455- Capital	SG-42-073 to 074	Stevens Gulch	Copper Wreath	--	Waste rock		47.02688693	-112.3677282	5,873	--	33	--	--	Possible adit location with tailings in waste rock pile.	X	
SG-43	456- Stevens Gulch	SG-43-075 to 078	Stevens Gulch	Capital	Capital Tunnel 15	Exploratory pit		47.02449884	-112.3690797	6,266	625 cy	778	--	--	Exploratory pit with possible tailings. Photo 78 of ridge to the NE, no mining activity evident. Numerous roadcuts.	X	
SG-44	457- Viking Mine	SG-44-079 to 083	Stevens Gulch	--	Viking Mine	Adit		47.02375696	-112.3730159	6,227	27778 cy	20,000	--	--	Tailings pile in contact with intermittent portion of Stevens Creek.	X	X

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Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
SG-45	458- Stevens Gulch	SG-45-084 to 085	Stevens Gulch	Capital No. 2	--	Exploratory drill pad		47.02658267	-112.3725299	5,925	6750 sf	23	--	--	Open well casing (16 inches). Possible safety hazard. Drilling deposition downslope.	X	
SG-46	459- Stevens Gulch	SG-46-086 to 088	Stevens Gulch	--	--	Exploratory drill pad		47.02706228	-112.3713408	5,781	15960 sf	15	--	--	Assess road and exploratory pad over possible adit location. Drilling debris downslope with possible tailings.	X	
SG-47	460- Stevens Gulch	SG-47-089 to 090	Stevens Gulch	Capital	Capital Tunnel 12	Adit	X	47.0265136	-112.3702679	5,712	1350 sf	278	--	--	Potential adit location. Tailings material in creek.	X	
SG-48	461- Stevens Gulch	SG-48-091 to 94	Stevens Gulch	Capital	Capital Tunnel 11	Adit	X	47.02638804	-112.37061	5,856	12 sf	28	--	--	adit in rock face adjacent to creek. Tailings material in creek.	X	
SG-49	462- Stevens Gulch	SG-49-095	Stevens Gulch	Denver	Tunnel 9	Waste rock		47.02731198	-112.3698857	5,741	--	999	--	--	Waste rock associated with adit SG-51. Located adjacent to ephemeral creek.	X	
SG-50	463- Stevens Gulch	SG-50-096	Stevens Gulch	Denver	Tunnel 9	Adit	X	47.02716655	-112.3695823	5,741	3 cy	28	--	--	Adit entrance under rock overhang.	X	
SG-51	464- Stevens Gulch	SG-51-097 to 098	Stevens Gulch	Denver	--	Exploratory drill pad		47.02760367	-112.3703389	5,741	9000 cy	370	--	--	Large cutslope with waste rock pushed into creek.	X	
SG-52	465- Stevens Gulch	--	Stevens Gulch	Denver	--	Survey site		47.02754064	-112.370982	5,735	--	--	--	--	Capital claim marker		
SG-53	466- Stevens Gulch	SG-53-099 to 101	Stevens Gulch	Capital No. 2	Tunnel 22	Waste rock		47.02740619	-112.3726238	5,748	--	2,843	--	--	Three waste rock piles and a large dig out area.		
SG-54	467- Stevens Gulch	--	Stevens Gulch	Capital No. 2	--	Exploratory drill pad		47.02758866	-112.3734587	5,869	--	7	--	--	Possible tailings in waste rock.	X	
SG-55	468- Stevens Gulch	SG-55-142	Stevens Gulch	Capital No. 2	--	Exploratory drill pad		47.02750895	-112.3737973	5,892	13000 sf	200	X	650	Pipe (4 inch) protruding from toe of cutslope leaking small amounts of water.	X	X
SG-56	469- Stevens Gulch	SG-56-102 to 103	Stevens Gulch	B	--	Waste rock		47.02713612	-112.3748404	5,958	875 sf	370	--	--	Possible tailings in waste rock.	X	
SG-57	470- Stevens Gulch	--	Stevens Gulch	B	--	Exploratory drill pad		47.02688023	-112.374954	6,040	10000 sf	--	--	--	No tailings evident.		
SG-58	471- Stevens Gulch	SG-58-104 to 105	Stevens Gulch	B	--	Exploratory drill pad		47.02649273	-112.3764518	6,247	7360 sf	1,481	--	--	Possible tailings in waste rock.	X	
SG-59	472- Stevens Gulch	SG-59-106 to 107	Stevens Gulch	--	--	Exploratory drill pad		47.02425878	-112.3743948	6,381	8000 sf	--	--	--	No tailings evident.		

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Site/Map ID Number	Field Book ID	Photo Number	Drainage	Associated Mine Claim	Associated Mine or Mine Feature[1]	Site Type	Adit Entrance Observed in Field	Site Location		Elev. (feet AMSL)	Estimated Disturbance for Exploratory Pads and Adits (sf) and Exploratory Pits and Trenches (cy)[2]	Waste Rock Pile Estimated Volume (cy)	Surface Water/ Seep Observed in Field	Distance to Nearest Observed Surface Water Feature (feet)	Comments/Notes	2008 Recommended Sampling	
								Latitude	Longitude							Soil	Surface Water
SG-60	472- Stevens Gulch	SG-60-108 to 109	Stevens Gulch	--	--	Trench		47.02425878	-112.3743948	6,381	--	5	--	--	Old hand dug trench. No tailings evident.		
SG-61	472- Stevens Gulch	--	Stevens Gulch	--	--	Trench		47.02425878	-112.3743948	6,381	--	5	--	--	Old hand dug trench. No tailings evident.		
SG-62	473- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.0251652	-112.3752127	6,371	7200 sf	--	--	--	Drilling debris downslope. Possible tailings in waste rock.	X	
SG-63	474- Stevens Gulch	SG-63-110 to 115	Stevens Gulch	--	--	Mine workings		47.02513989	-112.3759722	6,470	404 cy	--	--	--	Large amount of disturbance with numerous trenches and waste rock piles. Possible tailings in waste rock piles.	X	
SG-64	475- Stevens Gulch	SG-64-112	Stevens Gulch	--	--	Trench		47.02410774	-112.3760751	6,509	556 cy	--	--	--	Associated with disturbance at location SG-68. No tailings evident.		
SG-65	476- Stevens Gulch	SG-65-117	Stevens Gulch	--	--	Exploratory pit		47.02530183	-112.3773848	6,496	11 cy	--	--	--	No tailings evident.		
SG-66	477- Stevens Gulch	SG-66-118 to 119	Stevens Gulch	--	--	Exploratory pit		47.02565353	-112.377866	6,434	28 cy	--	--	--	No tailings evident.		
SG-67	478- Stevens Gulch	SG-67-120 to 122	Stevens Gulch	--	--	Exploratory drill pad		47.02548506	-112.3762017	6,358	4800 sf	19,444	--	--	Large amount of waste rock associated with two cut slopes. Possible tailings in waste rock piles.	X	
SG-68	479- Stevens Gulch	SG-68-123	Stevens Gulch	Capital No. 2	--	Exploratory drill pad		47.0293207	-112.3757673	5,922	--	44	--	--	Drill debris downslope. No tailings evident.		
SG-69	480- Stevens Gulch	SG-69-124	Stevens Gulch	--	--	Exploratory dig out		47.02970132	-112.3745474	5,771	18 cy	13	--	--	Point-of-discovery and associated dig out.		
SG-70	481- Stevens Gulch	SG-70-125 to 126	Stevens Gulch	--	--	Cabins		47.02835376	-112.371297	5,614	1000 sf	--	--	--	Four old cabins in various states of decay.		
SG-71	482- Stevens Gulch	SG-71-127 to 130	Stevens Gulch	Denver	--	Adit		47.02941902	-112.3728964	5,551	700 sf	463	X	70	Spring at possible adit location 70 feet from creek. Water has pooled and is 6 inches deep. Vegetation is in good condition adjacent to pond.		
SG-72	483- Stevens Gulch	--	Stevens Gulch	Denver	--	Survey site		47.03009435	-112.3735878	5,584	--	--	--	--	Denver claim corner marker.		

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								Latitude	Longitude							Soil	Surface Water
SG-73	484- Stevens Gulch	SG-73-131 to 132	Stevens Gulch	--	--	Exploratory drill pad		47.03331677	-112.3755916	5,686	4950 sf	11	--	--	No tailings evident.		
SG-74	485- Stevens Gulch	SG-74-133	Stevens Gulch	--	--	Exploratory drill pad		47.03376814	-112.3743896	5,561	4000 sf	--	--	--	No tailings evident.		
SG-75	486- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory dig out		47.03342649	-112.3745879	5,594	500 sf	--	--	--	No tailings evident.		
SG-76	487- Stevens Gulch	--	Stevens Gulch	--	--	Ground disturbance		47.03369848	-112.3727658	5,410	900 sf	--	--	--	Possible shop or staging area with a dump and timbers from a structure. Possible tailings along roadcut.	X	
SG-77	488- Stevens Gulch	--	Stevens Gulch	--	--	Waste rock		47.03274144	-112.3730226	5,492	--	7	--	--	Possible tailings deposit 10 feet from creek.	X	
SG-78	489- Stevens Gulch	SG-78-134 to 135	Stevens Gulch	--	--	Exploratory drill pad/ adit		47.03118844	-112.3718187	5,689	10000 sf	741	--	--	Possible adit location with tailings in waste rock pile.	X	
SG-79	490- Stevens Gulch	--	Stevens Gulch	--	--	Culvert in stream		47.03123856	-112.3729163	5,574	--	--	--	--	Old culvert from road crossing, no longer functional.		
SG-80	491- Stevens Gulch	SG-80-136 to 137	Stevens Gulch	--	--	Exploratory drill pad		47.03109297	-112.3739448	5,574	4000 sf	--	--	--	Possible old mine works with timbers and other older debris	X	
SG-81	492- Stevens Gulch	SG-81-138	Stevens Gulch	--	--	Trench		47.03159622	-112.3731582	5,551	22 cy	4	--	--	No tailings evident.		
SG-82	493a- Stevens Gulch	--	Stevens Gulch	--	--	Water quality		47.03159622	-112.3731582	5,551	--	156	--	--	Soil contributing to iron staining in creek, likely native material.	X	
SG-83	493b- Stevens Gulch	--	Stevens Gulch	--	--	Survey site		47.03238554	-112.3725435	5,515	--	--	--	--	"G2" claim marker.		
SG-84	494- Stevens Gulch	--	Stevens Gulch	--	--	Waste rock		47.03300262	-112.3728382	5,427	1750 sf	--	--	--	Bog area with noticeable increase in iron staining in stream below bog. Possible tailings deposited throughout.	X	X
SG-85	495- Stevens Gulch	SG-85-139	Stevens Gulch	--	--	Exploratory drill pad		47.03456081	-112.3751743	5,587	3200 sf	--	--	--	No tailings evident.		
SG-86	496- Stevens Gulch	SG-86-140 to 141	Stevens Gulch	--	--	Waste rock		47.03511327	-112.3753531	5,627	--	2,105	--	--	Two waste rock piles with possible tailings.	X	
SG-87	497- Stevens Gulch	--	Stevens Gulch	--	--	Exploratory drill pad		47.03488151	-112.3739187	5,587	2850 sf	--	--	--	Drilling debris downslope with possible tailings.	X	

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SWG-01	427-Carbonate	SWG-01-030	Swamp Gulch	--	--	Exploratory pit		47.04368443	-112.3968741	5,351	15 cy	3	--	--	Small dig out. No tailings evident.		
SWG-02	428-Carbonate	SWG-02-031-32	Swamp Gulch	Carbonate No. 3	--	Trench		47.04357991	-112.3995165	5,328	2037 cy	244	--	--	Possible tailings in waste rock piles.	X	
SWG-03	429-Carbonate	SWG-03-033	Swamp Gulch	Carbonate No. 3	--	Exploratory pit		47.04333826	-112.3992525	5,262	56 cy	11	--	--	Small dig out. No tailings evident.	X	
SWG-04	430-Carbonate	SWG-04-034	Swamp Gulch	Carbonate No. 3	Tunnel No. 2	Exploratory pit		47.04313994	-112.3990172	5,197	89 cy	11	--	--	Small dig out. No tailings evident.	X	
SWG-05	431-Carbonate No. 3	SWG-05-035 to 038	Swamp Gulch	Carbonate No. 3	Tunnel No. 2	Exploratory pit		47.04312167	-112.3987724	5,187	347 cy	--	--	--	Possible tailings in waste rock piles.	X	
SWG-06	431-Carbonate No. 4	--	Swamp Gulch	Carbonate No. 3	Tunnel No. 2	Trench		47.04312167	-112.3987724	5,187	22 cy	11	--	--	Possible tailings in waste rock piles. Cement footing, stove pipe and other debris.	X	
SWG-07	432 to 433-Carbonate	SWG-07-039	Swamp Gulch	--	--	Road		47.04110716	-112.3970316	5,187	622 cy	--	--	--	Possible tailings in roadbed.		
SWG-08	434 to 435-Carbonate	--	Swamp Gulch	Carbonate No. 3	--	Road		47.04221726	-112.3985684	5,174	346 cy	--	--	--	Possible tailings in roadbed.	X	
SWG-09	436-Carbonate	SWG-09-040 to 042	Swamp Gulch	Carbonate No. 2	--	Mine workings		47.04324145	-112.3953341	5,213	--	50	--	--	Mine workings and large footings on a constructed bench. Some waste rock but no tailings evident.		
SWG-10	437-Carbonate	SWG-10-043	Swamp Gulch	Carbonate No. 2	--	Ground disturbance		47.04340406	-112.3945718	5,266	--	--	--	--	No tailings evident.		
SWG-11	438-Carbonate No. 2	--	Swamp Gulch	Carbonate No. 2	Tunnel No. 2	Tunnel		47.04356113	-112.3941012	5,276	--	--	--	--	Revegetation in good condition.		
SWG-12	439-Carbonate	SWG-12-044 to 045	Swamp Gulch	--	--	Adit		47.04515286	-112.3935982	5,226	--	--	--	--	No tailings evident.		

cy = cubic yards
sf= square feet
AMSL = above mean sea level
Latitude and longitude measured using a hand-held resource grade global positioning satellite unit. GPS settings were NAD83 UTM.
[1]Association with historic features is an approximation as many historic mine area have been disturbed or removed completely.
2 cubic yard for estimated disturbance of exploratory pits and trenches is an estimate of the length, width, and depth of the disturbed area
-- Info Not available

Table B- 2
Sampling Summary for Surface Water, Sediment, and Macroinvertebrate Sampling Locations

Location Information						Investigation Type					Surface Water Analyses			Sediment Analyses	Aquatics Analyses		
Line Entry	Surface Water Body	Location Type (s)	Station Number	Media Type	Sediment Sample Depth Intervals	Proposed Sample ID	Source	Nature and Extent, and Risk	RD	Stream Gage (General Location)	Field[1]	Common Anions and Cations[2]	Metals[3]	Metals[4]	Taxonomy	Metals	Rationale / Comments
1	MH	SW	BRSW-4	SW	--	--	X	X	X	above anticipated seepage area, at station location, below anticipated seepage area but above confluence with Beartrap Creek/tailings outfall	X	X	X	--	--	--	Evaluate potential loading from seeps and waste removal areas.
2	MH	SW	BRSW-44	SW	--	--	X	X	X	above anticipated seepage area, at station location, below anticipated seepage area but above confluence with Beartrap Creek/tailings outfall	X	X	X	--	--	--	Evaluate loading from tailings deposits and tailings dam seeps.
3	BC	SW	BRSW-23	SW	--	--	X	X	X	above waste piles, at sample location, below waste piles	X	X	X	--	--	--	Evaluate potential metals loading from tailings and mine waste deposits.
4	BC	SW	BRSW-39A	SW	--	--	X	X	X	at station location	X	X	X	--	--	--	Evaluate loading from tailings and mine waste deposits.
5	AC	SW, SE, AQ	BRSW-6	SW, SE, AQ		--	X	X	X	at station location	X	X	X	X	X	X	Good water quality stream. Evaluate stream as possible background or reference stream for water, sediment, and aquatic organisms.
6	BR	SW	BRSW-29	SW	--	--	X	X	X	at station location	X	X	X	--	--	--	Evaluate potential metals loading and possible change in concentration following confluence of Anaconda Creek.
7	BR	SW	AW-003	SW	--	--	X	X	X	at station location	X	X	X	--	--	--	Evaluate metals load from constructed wetlands outflow.
8	BR	SW, SE, AQ	BRSW-109	SW, SE, AQ	0-2"	BRSW-109	X	X	X	at station location	X	X	X	X	X	X	Evaluate metals in water and sediment from potential loading from tailings/mine waste. Evaluate affects on aquatics
9	BR	SW, SE	BRSW-9	SW, SE	0-2"	--	X	X	X	at station location	X	X	X	X	--	--	Evaluate metal load in water and sediment on Blackfoot River above confluence with Stevens Creek
10	BR	SW, SE, AQ	BRSW-108	SW, SE, AQ	0-2"	BRSW-108	X	X	X	at location and on Stevens Creek	X	X	X	X	X	X	Evaluate metal in water and sediment following Blackfoot River below confluence with Stevens Creek. Evaluate affect on aquatics
11	BR	SW, SE	BRSW-36	SW, SE	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment above Shave Creek. Evaluate affects on aquatics
12	BR	SW, SE, AQ	BRSW-33	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load to water and sediment below Shave Creek. Evaluate affects on aquatics.
13	BR	SW, SE, AQ	BRSW-12	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment prior to entering marsh. Evaluate affects on aquatics.
14	PD	SW, SE, AQ	BRSW-11	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate possible background metals concentrations in water and sediment from Pass Creek. Evaluate health of aquatics.

Table B- 2
Sampling Summary for Surface Water, Sediment, and Macroinvertebrate Sampling Locations

Location Information						Investigation Type					Surface Water Analyses			Sediment Analyses	Aquatics Analyses		
Line Entry	Surface Water Body	Location Type (s)	Station Number	Media Type	Sediment Sample Depth Intervals	Proposed Sample ID	Source	Nature and Extent, and Risk	RD	Stream Gage (General Location)	Field[1]	Common Anions and Cations[2]	Metals[3]	Metals[4]	Taxonomy	Metals	Rationale / Comments
15	PM	SW, SE, AQ	BRSW-21	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment from Paymaster Creek. Evaluate affect on aquatics.
16	PM	SW, SE, AQ	BRSW-13	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment from Paymaster Creek. Evaluate affect on aquatics.
17	BR	FW	BMSP-2	FW	--	--	X	X	X	at station location	X	X	X	--	--	--	Possible abandoned flowing exploration well in marsh. Sample if flowing, note if abandoned.
18	BR	SW, SE, AQ	BRSW-110	SW, SE, AQ	--	BRSW-110	X	--	X	at station location	X	X	X	X	X	X	Evaluate chemistry of surface water & sediment in marsh near BMSP-2. Evaluate aquatic organisms
19	BR	SW, SE, AQ	BRSW-107	SW, SE, AQ	0-2"	BRSW-107	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment in Upper Marsh. Evaluate affects on aquatics.
20	BR	SW, SE	BRSW-31	SW, SE	0-2"	--	X	X	X	at station location	X	X	X	X	--	--	Evaluate metals in water and sediment below the confluence with Swamp Creek, Meadow Creek, and Porcupine Creek
21	BR	SW, SE, AQ	BRSW-106	SW, SE, AQ	0-2"	BRSW-106	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment above confluence with Surveyor Gulch. Evaluate aquatic organisms.
22	BR	SW, SE	BRSW-105	SW, SE	0-2"	BRSW-105	X	X	X	at station location	X	X	X	X	--	--	Evaluate metal load in water and sediment above Middle Marsh.
23	BR	SW, SE, AQ	BRSW-16	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment within central portion of Middle Marsh. Evaluate affects on aquatics.
24	BR	SW, SE, AQ	BRSW-104	SW, SE, AQ	0-2"	BRSW-104	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment between Middle March and Lower Marsh. Evaluate aquatic organisms.
25	BR	SW, SE, AQ	BRSW-103	SW, SE, AQ	0-2"	BRSW-103	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment within central portion of Lower Marsh. Evaluate affects on aquatics.
26	BR	SW, SE, AQ	BRSW-17	SW, SE, AQ	0-2"	--	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment below Lower Marsh. Evaluate affects on aquatics.
27	BR	SW, SE, AQ	BRSW-102	SW, SE, AQ	0-2"	BRSW-102	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment approximately mid-way between Lower Marsh and Highway 279. Evaluate affects on aquatics.
28	BR	SW, SE, AQ	BRSW-101	SW, SE, AQ	0-2"	BRSW-101	X	X	X	at station location	X	X	X	X	X	X	Evaluate metal load in water and sediment upstream of Highway 279 bridge. Evaluate affects on aquatics.

NOTES:
1 - Field parameters include: dissolved oxygen, temperature, pH, specific conductance, and flow gaging
2 - Anions & Common cations include: sulfate, bicarbonate, carbonate, chloride, calcium, magnesium, potassium, sodium
3 - Metals (surface water) include: aluminum, arsenic, cadmium, copper, iron, lead, manganese, zinc
4 - Metals (Sediment and Aquatics) - arsenic, cadmium, copper, lead, manganese, mercury, zinc

Drainage Basin
BR-Blackfoot River
BC-Beartrap Creek
PD-Pass Creek Meadow
MH-Mike Horse Creek

Media
SE – Sediment
SW - Surface Water

AQ - Aquatics (macroinvertebrates, periphyton, etc.)
FW - Flowing Well
AC - Anaconda Creek

Table B- 3
Known Available Sediment Data

Number of Samples [1]	Sampling Map Available	Total Metals	TCLP	SPLP	ABA	Other	Purpose	Original Reference[2]
Alice Creek								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
5	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
5	Unknown	Yes					Blackfoot River Geochemical Baseline Study	Nagorski (2000)
Anaconda Creek								
2	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992) and Spence (1975b)
3	Figure 4-17, DEQ 2007 DSR	Yes					Final Site Inspection Report	MDHES (1994)
10	Unknown	Yes				Texture classification	Trace elements in floodplains	Vanderberg (2005)
7	Figure 4-17, DEQ 2007 DSR	Yes					Additional sediment sampling	Hydrometrics (1996)
Blackfoot River Channel								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
3	Figure 4-17, DEQ 2007 DSR	Yes				Cyanide and Total Organic Carbon	Phase 1	PTI (1994)
Unknown	Unknown	Yes					Blackfoot River Geochemical Baseline Study	Nagorski (2000)
8	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992)
Blackfoot River Banks								
7	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)

Table B- 3
Known Available Sediment Data

Number of Samples [1]	Sampling Map Available	Total Metals	TCLP	SPLP	ABA	Other	Purpose	Original Reference[2]
30	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Blackfoot River Floodplains								
135	Unknown	Yes				Texture classification	Trace elements in floodplains	Vanderberg (2005)
Blackfoot River - Other Sites								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
7	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992)
Beartrap Creek								
Unknown	Figure 4-17, DEQ 2007 DSR						Final Site Inspection Report	MDHES (1994)
Unknown	Unknown	Yes					Unknown – collected by MBMG	Hydrometrics (2007)
9	Unknown	Yes				Texture classification	Trace elements in floodplains	Vanderberg (2005)
Unknown	Unknown	Yes				Cyanide and Total Organic Carbon	Phase 1	PTI (1994)
Cadotte Creek								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
2	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Hogum Creek								
1	Unknown	Yes					Blackfoot River Geochemical Baseline Study	Nagorski (2000)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
1	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)

Table B- 3
Known Available Sediment Data

Number of Samples [1]	Sampling Map Available	Total Metals	TCLP	SPLP	ABA	Other	Purpose	Original Reference[2]
Horsefly Creek								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Hardscrabble Creek								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
1	Unknown	Yes					Blackfoot River Geochemical Baseline Study	Nagorski (2000)
Marshes								
15	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992)
Meadow Creek								
1	Unknown	Yes					Blackfoot River Geochemical Baseline Study	Nagorski (2000)
Mike Horse Creek								
1	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992)
Unknown	Unknown	Yes					Unknown – collected by MBMG	Hydrometrics (2007)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
2	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
1	Unknown		Yes			Acid extractable metals	Phase 1 EA	MFG (1994a)
Unknown	Figure 4-17, DEQ 2007 DSR						Final Site Inspection Report	MDHES (1994)
Unknown	Unknown					Metals analyzed with XRF	Additional sediment sampling	Hydrometrics (1996)

Table B- 3
Known Available Sediment Data

Number of Samples [1]	Sampling Map Available	Total Metals	TCLP	SPLP	ABA	Other	Purpose	Original Reference [2]
Pass Creek								
12	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Unknown	Unknown						Final Site Inspection Report	MDHES (1994)
1	Unknown	Yes					Blackfoot River Geochemical Baseline Study	Nagorski (2000)
Paymaster Creek								
1	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Unknown	Figure 4-17, DEQ 2007 DSR						Final Site Inspection Report	MDHES (1994)
Unknown	Unknown						Additional sediment sampling	Hydrometrics (1996)
Unknown	Unknown					X-Ray Spectroscopy	Baseline Water Quality	Furniss (1995)
Unknown	Unknown	Yes				Total Organic Carbon	Phase 1	PTI (1994)
Shave Gulch								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Monitoring Program	Hydrometrics (1992)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Unknown	Figure 4-17, DEQ 2007 DSR						Final Site Inspection Report	MDHES (1994)
7	Figure 4-17, DEQ 2007 DSR	Yes					Additional sediment sampling	Hydrometrics (1996)

Table B- 3
Known Available Sediment Data

Number of Samples [1]	Sampling Map Available	Total Metals	TCLP	SPLP	ABA	Other	Purpose	Original Reference[2]
Stevens Gulch								
Unknown	Figure 4-17, DEQ 2007 DSR						Final Site Inspection Report	MDHES (1994)
Swamp Gulch								
Unknown	Unknown	Yes [3]					Metal bioavailability study	Moore (1990)
Unknown	Figure 4-17, DEQ 2007 DSR	Yes					Thesis, University of Montana	Menges (1997)
Unknown	Figure 4-17, DEQ 2007 DSR						Final Site Inspection Report	MDHES (1994)
Willow Creek								
Unknown	Figure 4-17, DEQ 2007 DSR	Yes [3]					Mine Effects on Non-Point Source Contaminants in the Blackfoot River	Moore (1990)

Notes:

[1] “Unknown” sample numbers can likely be deduced through review of data in original reports. See text for explanation.

[2] All references taken from DEQ (2007). These have not been reviewed and are provided for cross referencing purposes only. Refer to DEQ (2007) for complete reference.

[3] Data supplied in Appendix A Table A-3 Upper Blackfoot Mining Complex Historical Data – Sediments (DEQ 2007) are provided in mg/L. This is not typical for total whole-rock metal analysis. See text.

ABA = Acid-Base Accounting, SPLP = Synthetic Precipitate Leaching Procedure, TCLP = Toxicity Characteristic Leaching Procedure, XRF = X-Ray Fluorescence.

Table B- 4
Summary of Monitoring Well and Piezometer Inventory

Line Entry	General Location	Drainage Basin	Station Number	Media Type	Alluvial	Bedrock	Soil Sample Depth Intervals	Proposed Sample ID	Investigation Type[1]: Source	Investigation Type[1]: Nature and Extent	Investigation Type[1]: Risk	Investigation Type[1]: RD	Proposed Analyses: Field[2]	Proposed Analyses: Standard Analyte Suite[3]	Proposed Analyses: Metals[4,L]	Proposed Analyses: Water Levels[11]	Rationale / Comments	Estimated Total Depth (ft bgs)
1	At mouth of Porcupine Gulch / road to Meadow Gulch	BR	LCMW-1	GW	X	--	--	LCMW-1	--	X	X	--	X	X	X	X	Evaluate alluvial groundwater exiting UBMC	26
2	At mouth of Porcupine Gulch paired w/ LCMW-1	BR	BRGW-101	GW	--	X	--	BRGW-101	--	X	X	--	X	X	X	X	Evaluate bedrock groundwater exiting UBMC	85
3	Along Black Foot River at Mary P Prospect	BR	MPP-4	GW	X	--	--	MPP-4		X	X	--	X	X	X	X	Evaluate alluvial groundwater near Mary P Prospect paired w/ BRGW-110	
4	Along Black Foot River at Mary P Prospect	BR	BRGW-110	GW	--	X	--	BRGW-110	--	X	X	--	X	X	X	X	Evaluate bedrock groundwater near Mary P Prospect paired w/ MPP-4	41
5	At down stream end of Anaconda Mine constructed wetlands	BR	ANMW-7	GW	X	--	--	ANMW-7	X	X	X	--	X	X	X	X	Evaluate alluvial groundwater exiting the Anaconda Mine area and shallow Blackfoot River	22
6	Mouth of drainage near Highway 200	SW	LCMW-5	GW	X	--	--	LCMW-5	X	X	X	--	X	X	X	X	Evaluate alluvial groundwater exiting Carbonate Mine area	19
7	Mouth of drainage near Highway 200	SW	LCMW-12D	GW	X	--	--	LCMW-12D	X	X	X	--	X	X	X	X	Evaluate alluvial groundwater exiting Carbonate Mine area	30
8	Mouth of drainage near Highway 200	SW	LCMW-12S	GW	X	--	--	LCMW-12S	X	X	X	--	X	X	X	X	Evaluate alluvial groundwater exiting Carbonate Mine area	17
9	At top of Carbonate Mine repository	SW	SWGW-101	GW	X	--	--	SWGW-101	X	X	--	--	X	X	X	X	Alluvial well for repository monitoring	20
10	At bottom of Carbonate Mine repository paired w/ UCMW-11	SW	SWGW-102	GW	X	--	--	SWGW-102	X	X	X	--	X	X	X	X	Alluvial well for repository monitoring	20
11	Drainage bottom upstream of reclaimed area	SW	SWGW-103	GW	X	--	--	SWGW-103	--	X	--	--	X	X	X	X	Background well for mine reclamation area	20
12	At base or repository	SW	UCMW-11	GW	--	X	--	UCMW-11	X	X	--	--	X	X	X	X	Evaluate repository and bedrock groundwater	82
13	Paymaster mine	PM	PMMW-13	GW	X	X	--	PMMW-13	X	X	--	--	X	X	X	X	Alluvial bedrock interface with historic data in vicinity of mine site	18
14	Paymaster Mine	PM	PMMW-15	GW	X	--	--	PMMW-15	X	X	X	--	X	X	X	X	Alluvial well downstream of impacts	
15	Downgradient of Paymaster repository	PM	PMGW-116	GW	X	--	--	PMGW-116	--	X	--	--	X	X	X	X	Monitor downgradient of proposed repository expansion area	
16	Downgradient of Paymaster repository	PM	PMGW-117	GW	X	--	--	PMGW-117	--	X	--	--	X	X	X	X	Monitor downgradient of proposed repository expansion area	
17	Downstream of mine along edge of marsh paired w/ PMMW-119	PM	PMGW-118	GW	X	--	--	PMGW-118	--	X	--	--	X	X	X	X	Evaluate shallow groundwater downgradient of mine along edge of marsh system	40
18	Downstream of mine along edge of marsh paired w/ PMMW-118	PM	PMGW-119	GW	--	X	--	PMGW-119	--	X	--	--	X	X	X	X	Evaluate bedrock groundwater downgradient of mine along edge of marsh system	80
19	Paymaster mine near PMMW-15	PM	PMGW-120	GW	--	X	--	PMGW-120	X	X	X	--	X	X	X	X	Evaluate bedrock groundwater, in vicinity of gaining reach	60
20	Downstream of Mike Horse fault crossing in vicinity of veins	PM	PMMW-14	GW	X	--	--	PMMW-14	--	X	--	--	X	X	X	X	Alluvial well in vicinity of fault vein crossing drainage	22.5
21	Headwater reach	PM	PMPZ-4	GW	X	--	--	PMPZ-4	--	X	--	--	X	X	X	X	Alluvial well in headwaters of drainage to evaluate upstream of Mike Horse fault	8

Table B- 4
Summary of Monitoring Well and Piezometer Inventory

									Investigation Type[1]				Proposed Analyses					
Line Entry	General Location	Drainage Basin	Station Number	Media Type	Alluvial	Bedrock	Soil Sample Depth Intervals	Proposed Sample ID	Source	Nature and Extent	Risk	RD	Field[2]	Standard Analyte Suite[3]	Metals[4,L]	Water Levels[11]	Rationale / Comments	Estimated Total Depth (ft bgs)
22	Adjacent to county road in wet area	ED	EDP-2	GW	X	--	--	EDP-2	X	X	--	--	X	X	X	X	Evaluate shallow alluvial groundwater in vicinity of mining activities	25
23	West of Edith Mine waste rock piles	ED	EDMW-2	GW	X	--	--	EDMW-2	X	X	--	--	X	X	X	X	Evaluate shallow alluvial groundwater in vicinity of mining activities	
24	Edith Mine generally between EDMW-2 and EDP-2	ED	EDGW-105	GW	--	X	--	EDGW-105	X	X	--	--	X	X	X	X	Evaluate bedrock groundwater in vicinity of mining activities	80
25	Lower Stevens Gulch at switchback paired w/ SGGW-102	SG	SGGW-101	GW	X	--	--	SGGW-101	--	X	--	--	X	X	X	X	Evaluate bedrock groundwater at mouth of drainage	40
26	Lower Stevens Gulch at switchback paired w/ SGGW-101	SG	SGGW-102	GW	--	X	--	SGGW-102	--	X	--	--	X	X	X	X	Evaluate bedrock groundwater at mouth of drainage	80
27	Upstream end of Anaconda Mine reclamation area	AN	ANWS-1	GW	X	--	--	ANWS-1	--	X	--	--	X	X	X	X	Evaluate alluvial groundwater entering the Anaconda Mine area	--
28	~1500 feet upstream of Anaconda Mine	BC	BCMW-10	GW	X	--	--	BCMW-10	--	X	--	--	X	X	X	X	Evaluate alluvial groundwater in vicinity of projected Blackfoot Fault crossing	16
29	~1500 feet downstream of Dam along main road	BC	BCGW-115	GW	X	--	--	BCGW-115	--	X	--	--	X	X	X	X	Evaluate Blackfoot Fault crossing of channel, evaluate gaining/loosing reach	200-250
30	At switchback in access road to Dam	MH	MHMW-8	GW	--	X	--	MHMW-8	--	X	X	--	X	X	X	X	Evaluate shallow bedrock near mouth of Mike Horse Creek	25
31	At switchback in access road to Dam paired w/MHMW-8	MH	MHMW-109	GW	X	--	--	MHMW-109	--	X	X	--	--	--	--	--	Evaluate alluvial groundwater leaving Mike Horse Creek drainage	15
32	~500 feet upstream of MHMW-8 at toe of repository near seep area. Paired w/ MHGW-113	MH	MHMW-112	GW	X	--	--	MHMW-112	X	X	X	--	--	--	--	--	Alluvial well to monitor repository	15
33	~500 feet upstream of MHMW-8 at toe of repository near seep area. Paired with MHGW-112	MH	MHMW-113	GW	--	X	--	MHMW-113	X	X	X	--	--	--	--	--	Bedrock well to monitor repository	40
34	Mike Horse Mine site above water treatment	MH	UMHMW-3	GW	--	X	--	UMHMW-3	X	X	--	--	--	--	--	--	Evaluate upstream end of gaining reach above water treatment facility	15
35	Mike Horse Mine site above water treatment paired w/UMHMW-3	MH	MHMW-115	GW	--	X	--	MHMW-115	X	X	--	--	--	--	--	--	Evaluate alluvial groundwater quality from mine waste rock seepage entering repository area	15
36	Upslope of Mike Horse Mine seepage area	MH	UMHMW-1D	GW	--	X	--	UMHMW-1D	X	X	--	--	--	--	--	--	Evaluate groundwater quality from mine tailings seepage	42.5
37	Upslope of Mike Horse Mine seepage area	MH	UMHMW-1S	GW	X	--	--	UMHMW-1S	X	X	--	--	--	--	--	--	Evaluate groundwater quality from mine tailings seepage	15
38	Upslope of Mike Horse Mine seepage area	MH	UMHMW-2D	GW	--	X	--	UMHMW-2D	X	X	--	--	--	--	--	--	Evaluate groundwater quality from mine tailings seepage	11.5
39	Upslope of Mike Horse Mine seepage area	MH	UMHMW-2S	GW	X	--	--	UMHMW-2S	X	X	--	--	--	--	--	--	Evaluate groundwater quality from mine tailings seepage	19.5
40	Upstream of Mike Horse Mine adits near spring	MH	MW-1	GW	--	X	--	MW-1	X	X	--	--	--	--	--	--	Evaluate bedrock groundwater Mike Horse fault contributions to creek	--

NOTES (**Table B-4**):

<u>Drainage Basin</u>

PM-Paymaster Gulch
PD-Pass Creek Meadow
SG-Stevens Gulch
SW-Swamp Gulch
BR-Blackfoot River
ED-Edith Mine
BC-Beartrap Creek
AN-Anaconda Creek
MH-Mike Horse Creek

<u>Media</u>

GW - Groundwater

1. Some samples satisfy multiple investigation objectives.

-- Not Applicable

Field = specific conductance, pH, temperature, oxidation-reduction potential, dissolved oxygen

Metals=aluminum, arsenic, cadmium, copper, iron, manganese, mercury, zinc

Standard Analyte Suite = Common Cations (calcium, magnesium, potassium, sodium) and Common Anions (carbonate, bicarbonate, sulfate, chloride)

Table B- 5
Historic Benthic Results

Table B- 6
2007 Results of Metals Analysis